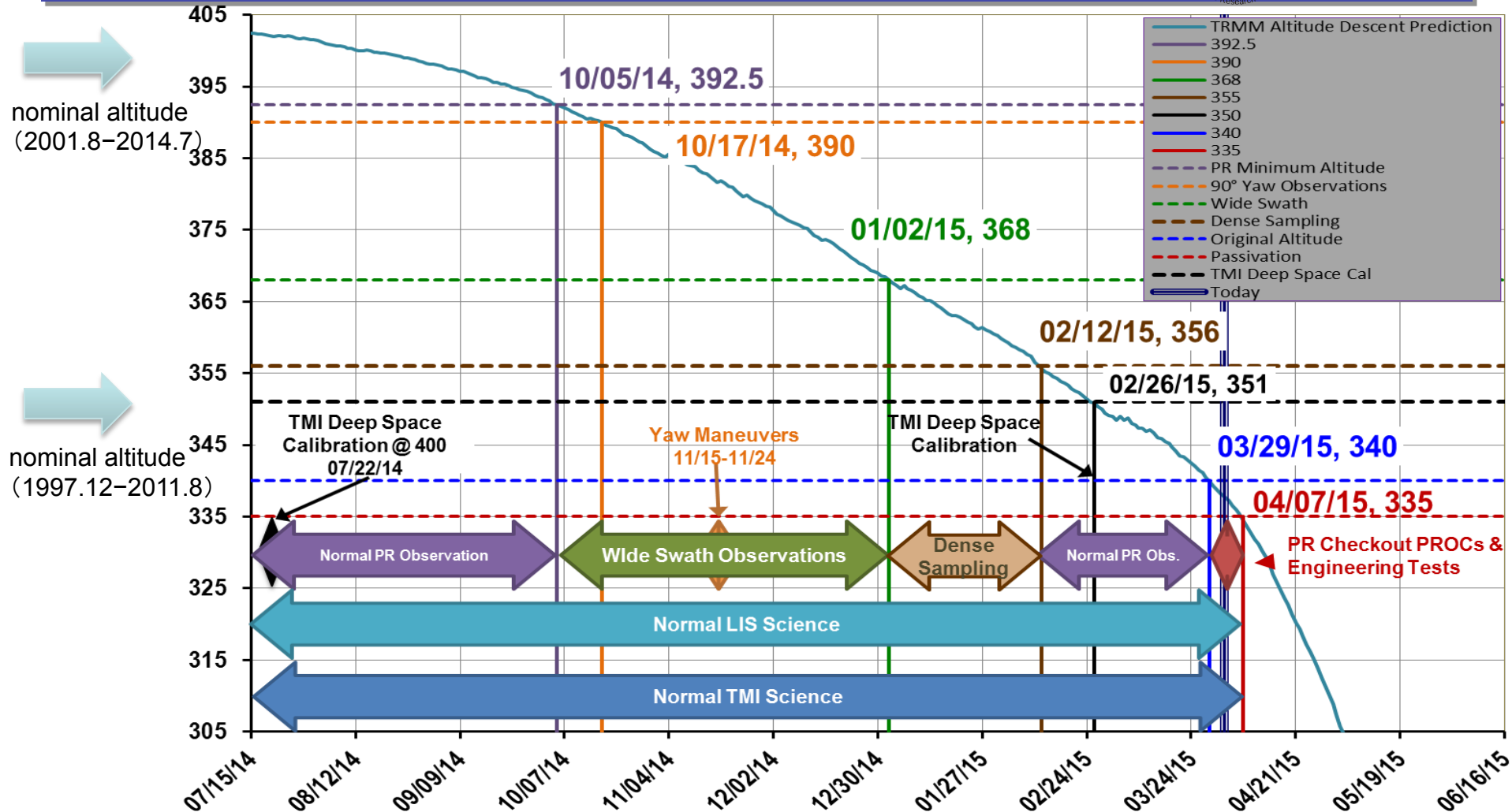


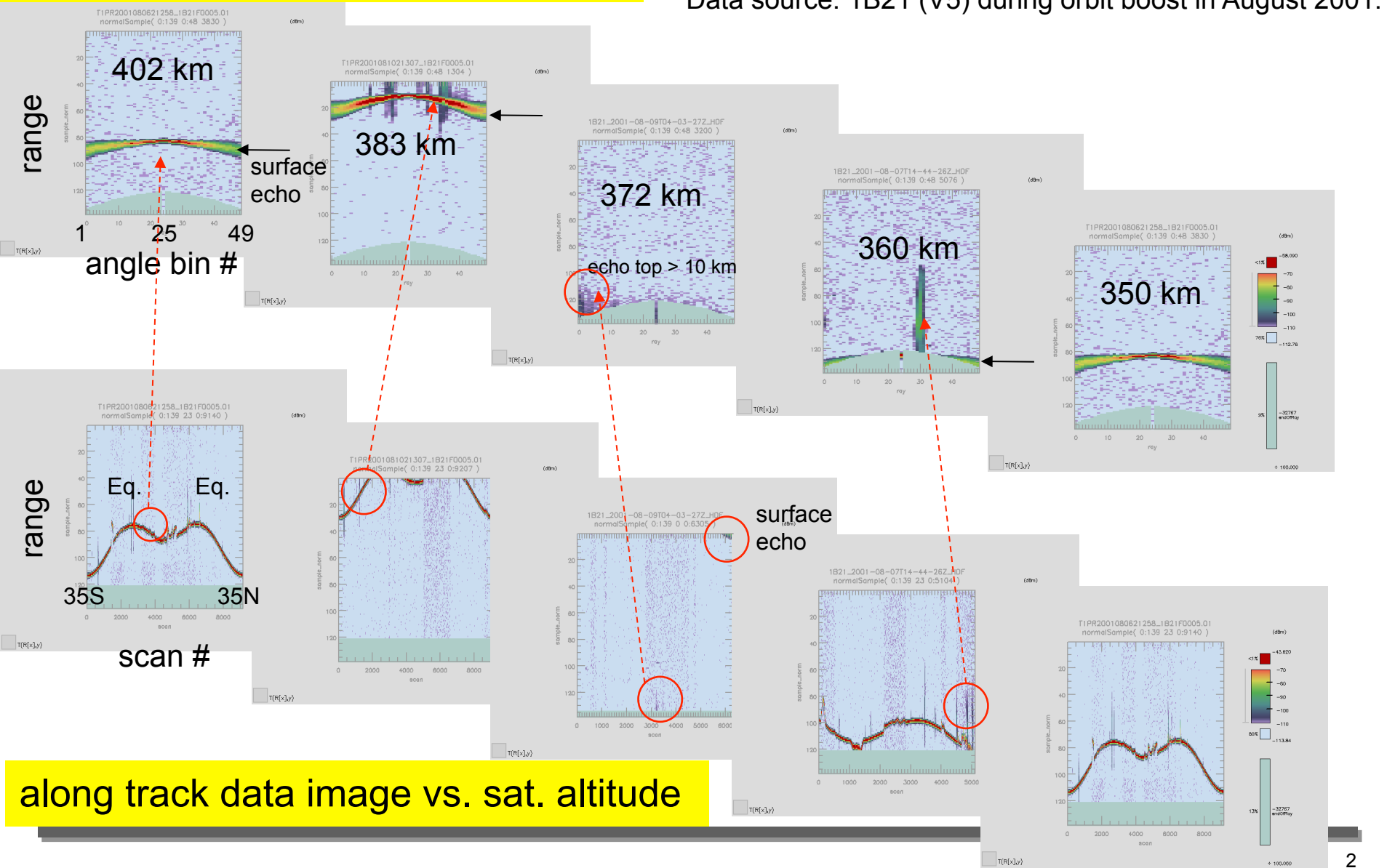
Satellite altitude (from NASA/FOT's presentation)



If the solar beta angle is less than 20 degrees, PR's operation was limited only day side of the orbit, because of battery issue.

scan data image vs. sat. altitude

Data source: 1B21 (V5) during orbit boost in August 2001.



Detailed experiment schedule (as Jul. 2014)

Experimental observation

	purpose	operation	altitude window(s) or duration	note
1	Nominal observation	1.Comparison with GPM/DPR. 2. Increase the rain record by radar. 3. Testing GSMaP.	Nominal observation 402.5 to 392.5 km And 355 to 340 km	Retrieved data may be valid until the radar observed up to 5 km in height.
2	Dense b sampling	Increase the data on the non uniform beam filling effect.	External cal. mode 357 to 355 km (10 days)	
2	Wider swath d experiment	To check the possibility to enlarge the swath	External cal. mode or Nominal obs. Mode 390 to 355 km (11 month)	Need to upload of the phase code for three times according to the satellite altitude.
3	90 deg. yaw a observation*	To obtain the detailed rain structure and sigma zero from various incident angle.	Nominal obs. mode with satellite yaw angle of 90 deg. 392 to 390 km (total 10 days)	4 yaw maneuvers per day and each time about 22 min. observation. Combining with wider scan experiment is preferable.
4	checkout	To obtain the engineering information of PR	Various modes Below 340 km	Implementation has not been decided.

Note: Altitude and duration of each experimental observation may change due to the satellite operation (e.g. 180 deg. Yaw turn) and the satellite condition.

*: see NASA's slides for GISM on 5 June 2014.

Table 1. TRMM EOM experiments (summary)

Experiment/events	Duration	Orbit number	SMA satellite altitude range
Normal observation	2014/7/16 – 2014/10/7*	–#93230	–392.0 km
Wide swath #1	2014/10/27–2014/11/15	#96537 – #96832	387.3 km – 382.5 km
90-degree yaw maneuver	2014/11/15–2014/11/25**	#96833 – #96993	382.5 km – 379.8 km
Wide swath #2	2014/11/24–2014/12/17	#96978 – #97333	379.8 km – 373.4 km
Wide swath #3	2014/12/17–2015/1/5	#97334 – #97634	373.4 km – 366.8 km
Dense sampling #1	2015/1/5–2015/1/24	#97635 – #97914	366.8 km – 361.9 km
Dense sampling #2	2015/1/24–2015/2/12	#97915 – #98231	361.9 km – 355.7 km
Normal observation	2015/2/12–	#98231 –	355.7 km – 340.0 km
Instrument checkout	2015/3/30–		340.0 km
Passivation of PR			

*: Data are open until 7 October for general users. Normal observation was implemented between 7 and 27 October.

**: 90-degree yaw orbits are listed in Table 2.

Summary of 90 degree yaw (90Y) experiment

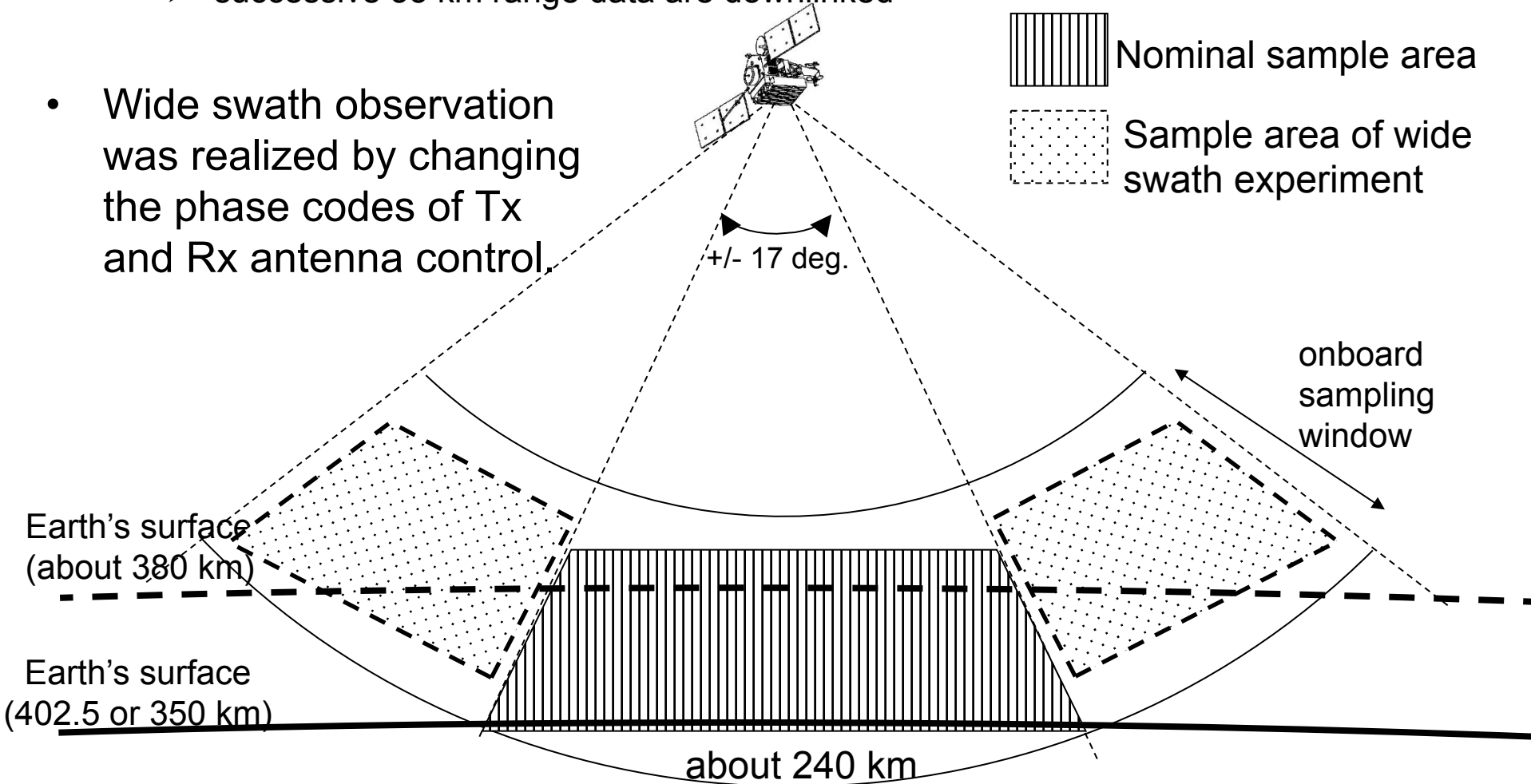
Table 2 0 orbits for 90-deg yaw experiment		
90-degree yaw maneuver	Experimental orbit number	Phase code
Day #1 (2014/11/15)	96834 96835 96836 96837 96838	90-degree yaw maneuver
Day #2 (2014/11/16)	96849 96850 96851 96852 96853	90-degree yaw maneuver
Day #3 (2014/11/17)	96865 96866 96867 96868 96869	90-degree yaw maneuver
Day #4 (2014/11/18)	96880 96881 96882 96883 96884	90-degree yaw maneuver
Day #5 (2014/11/19)	96896 96897 96898 96899 96900	90-degree yaw maneuver
Day #6 (2014/11/20)	96912 96913 96914 96915 96916	90-degree yaw maneuver
Day #7 (2014/11/21)	96927 96928 96929 96930 96931	90-degree yaw maneuver
Day #8 (2014/11/22)	96944 96945 96946 96947	90-degree yaw maneuver
Day #9 (2014/11/23)	96959 96960 96961 96962	90-degree yaw maneuver
Day #10 (2014/11/24)	96975 96976 96977 96978	90-degree yaw maneuver
Day #11 (2014/11/25)	96990 96991 96992 96993	Wide swath #2

Duration of 90-degree yaw mode was 20 minutes in each orbit and four (4) orbits per day.

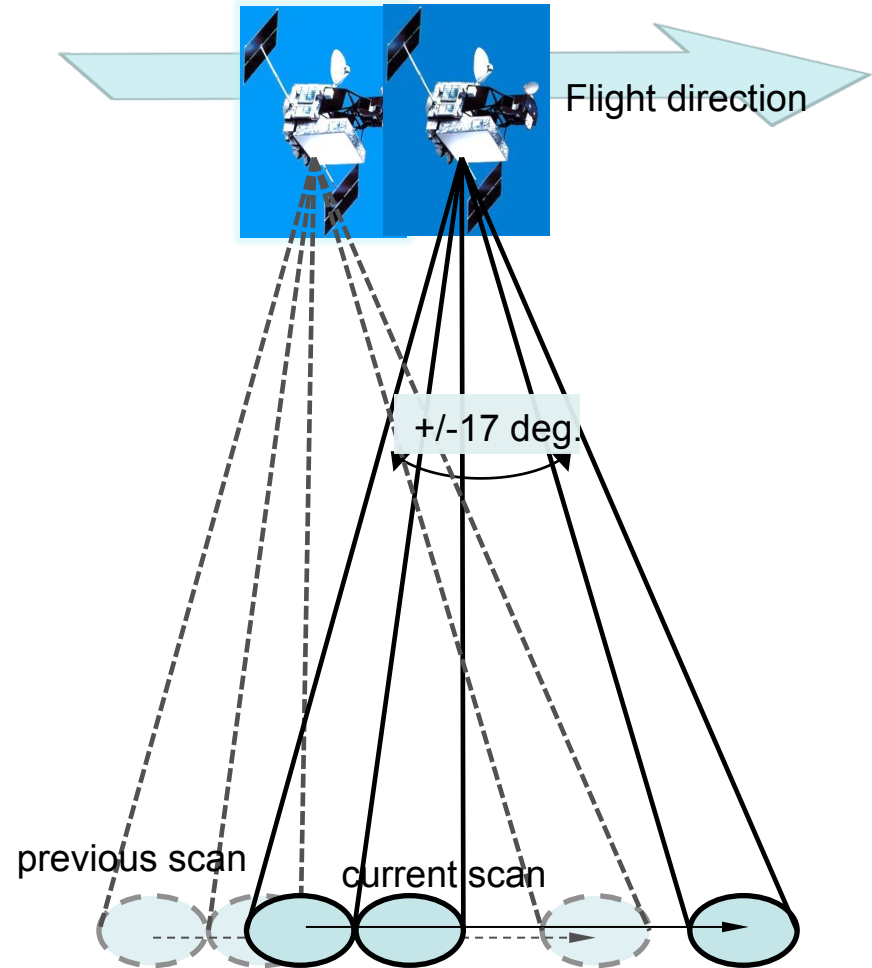
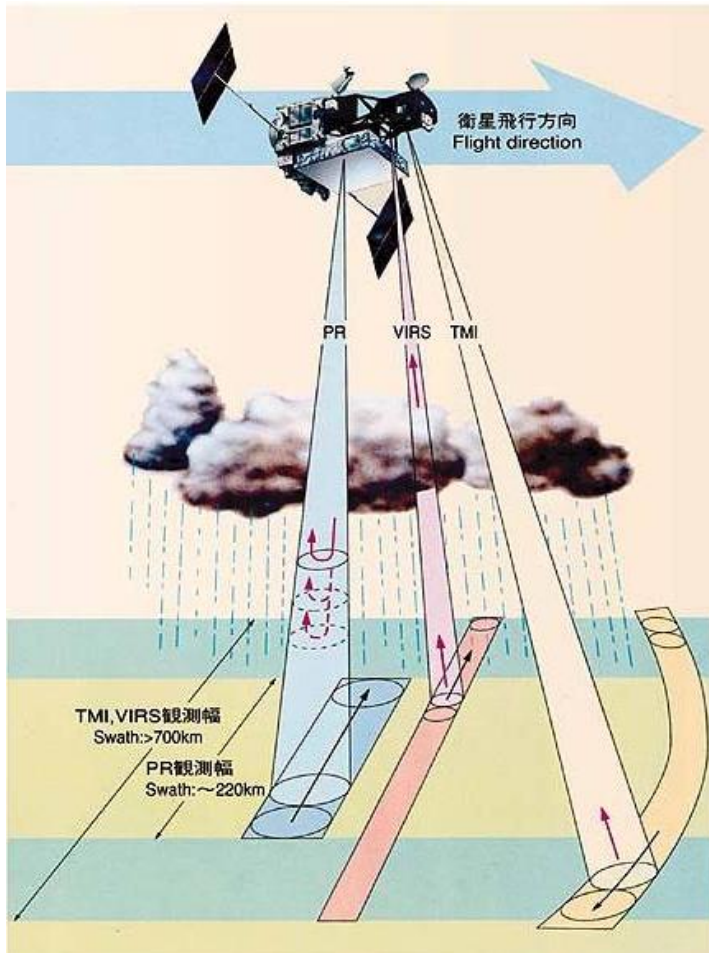
TRMM/PR data sampling:

- 49 angle bins for one scan
- fixed onboard sampling range (50 km window)
- successive 35 km range data are downlinked

- Wide swath observation was realized by changing the phase codes of Tx and Rx antenna control.

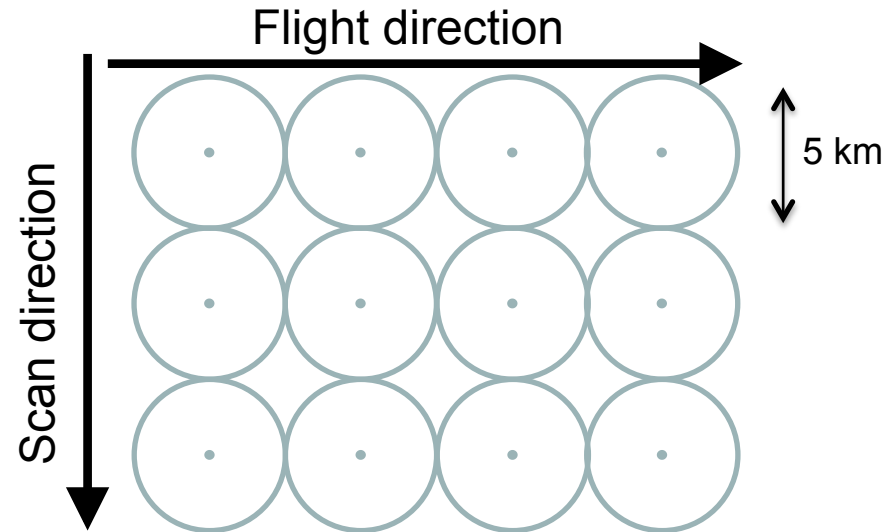


Nominal observation → 90 deg. yaw



This mode can obtain the rain structure with various incident angles.
TMI will also observe similar data.

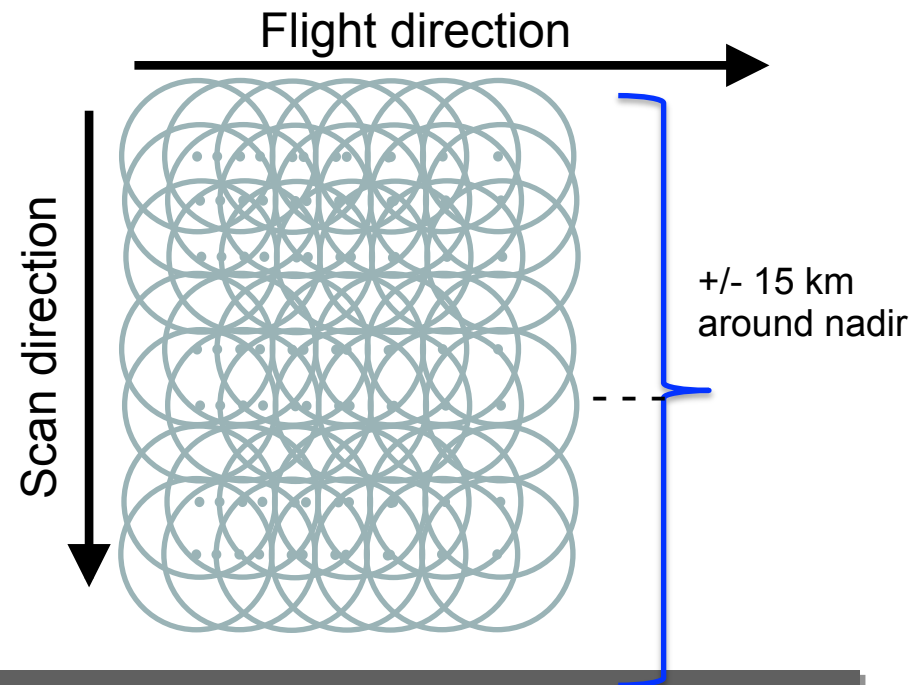
Nominal observation

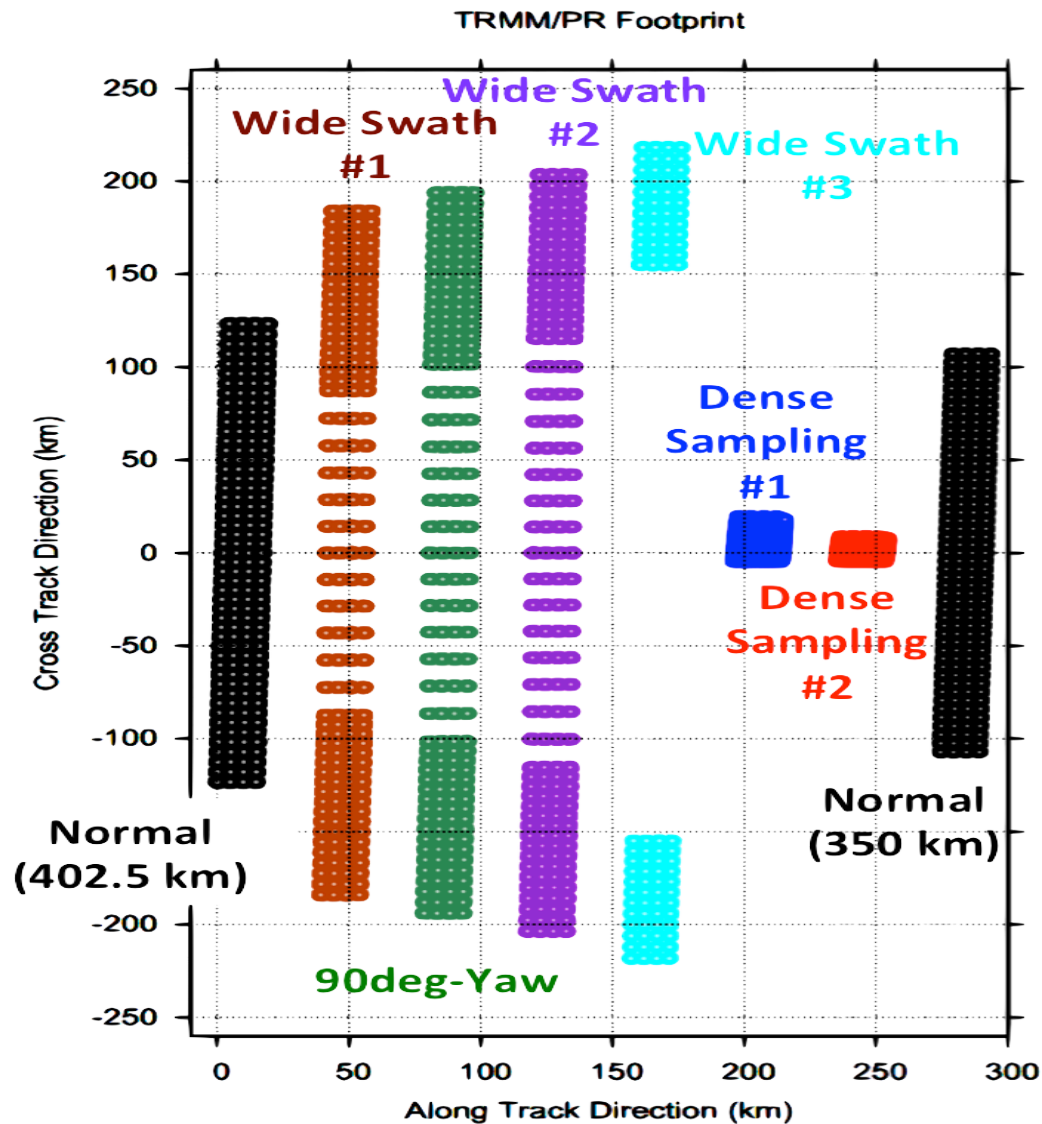


Dense sampling observation

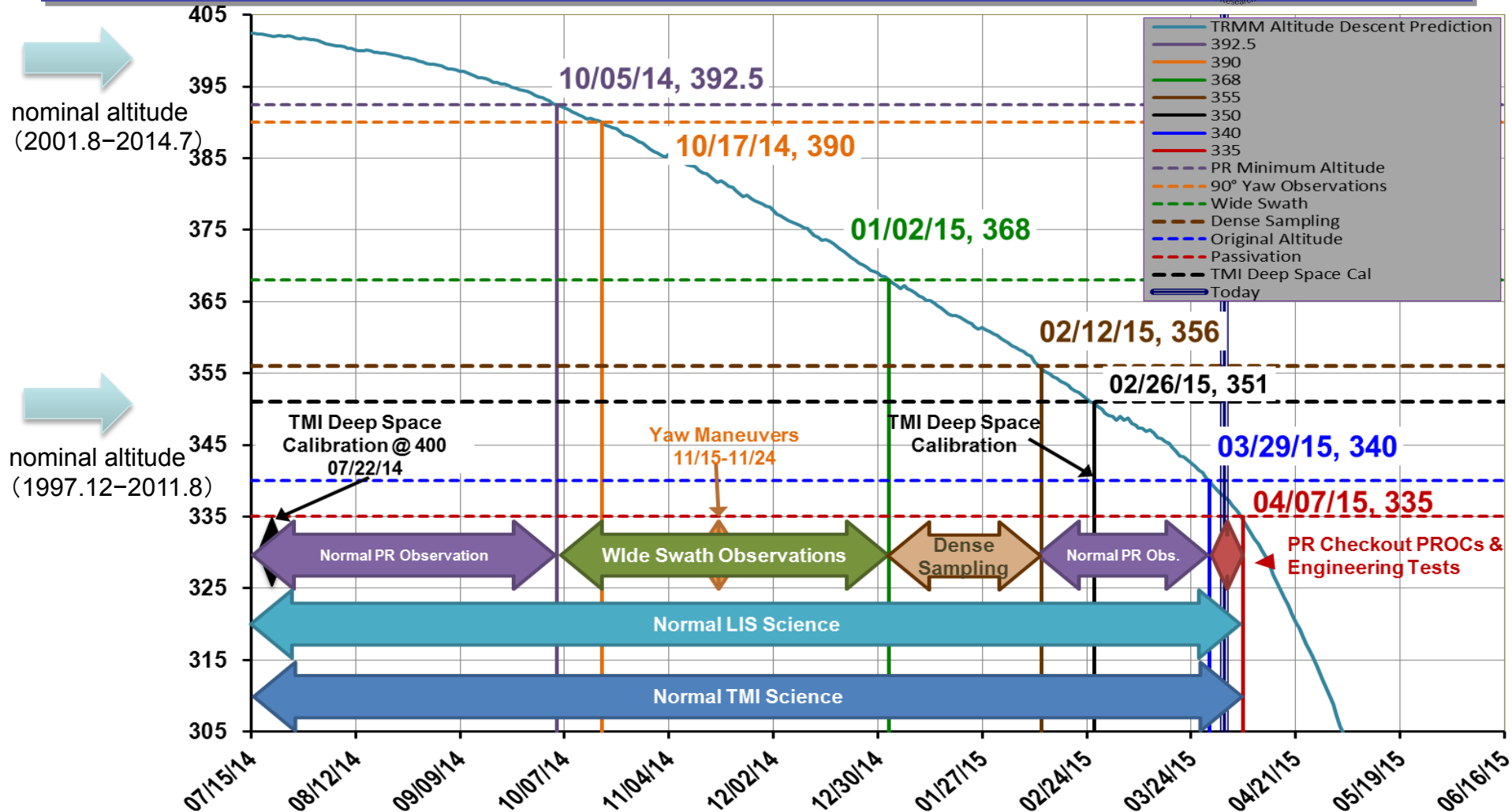
3/4 times dense for scan and flight direction

- ❖ This experiment was planned to implement external calibration mode.
- ❖ Actual experiment was done similar to the wide swath observation but the footprints are concentrated near nadir.





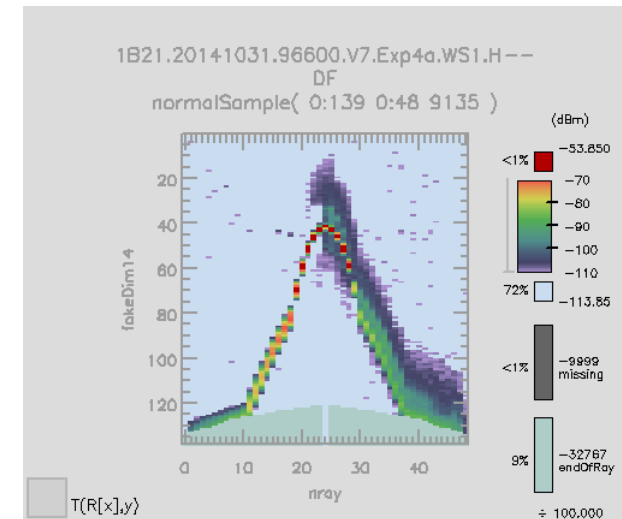
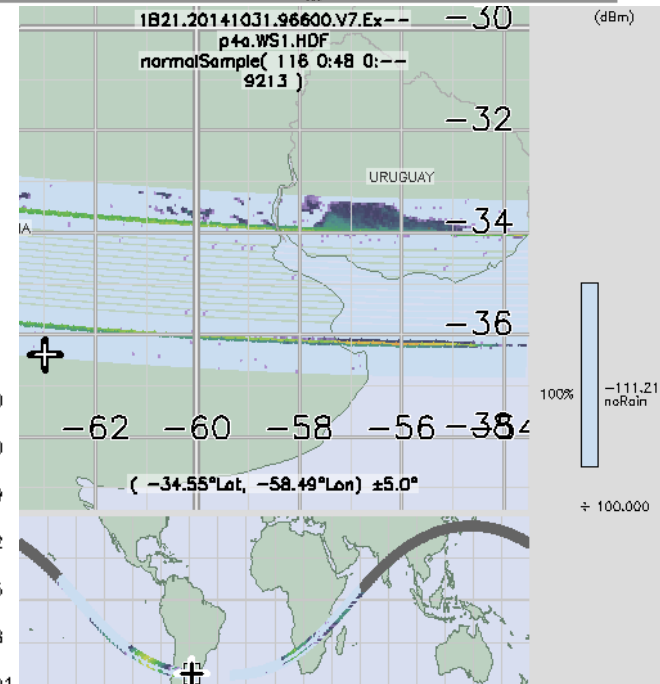
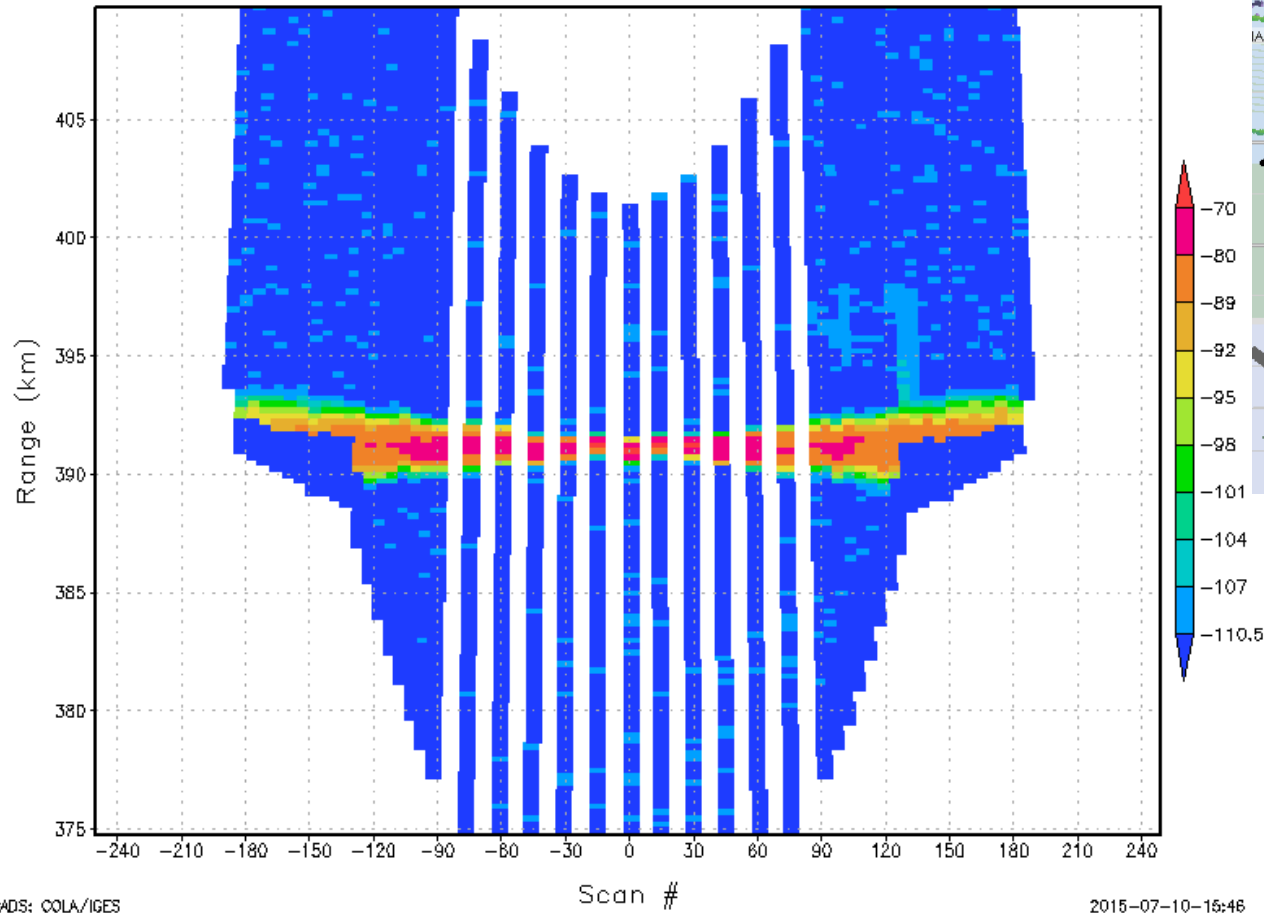
Satellite altitude (from NASA/FOT's presentation)

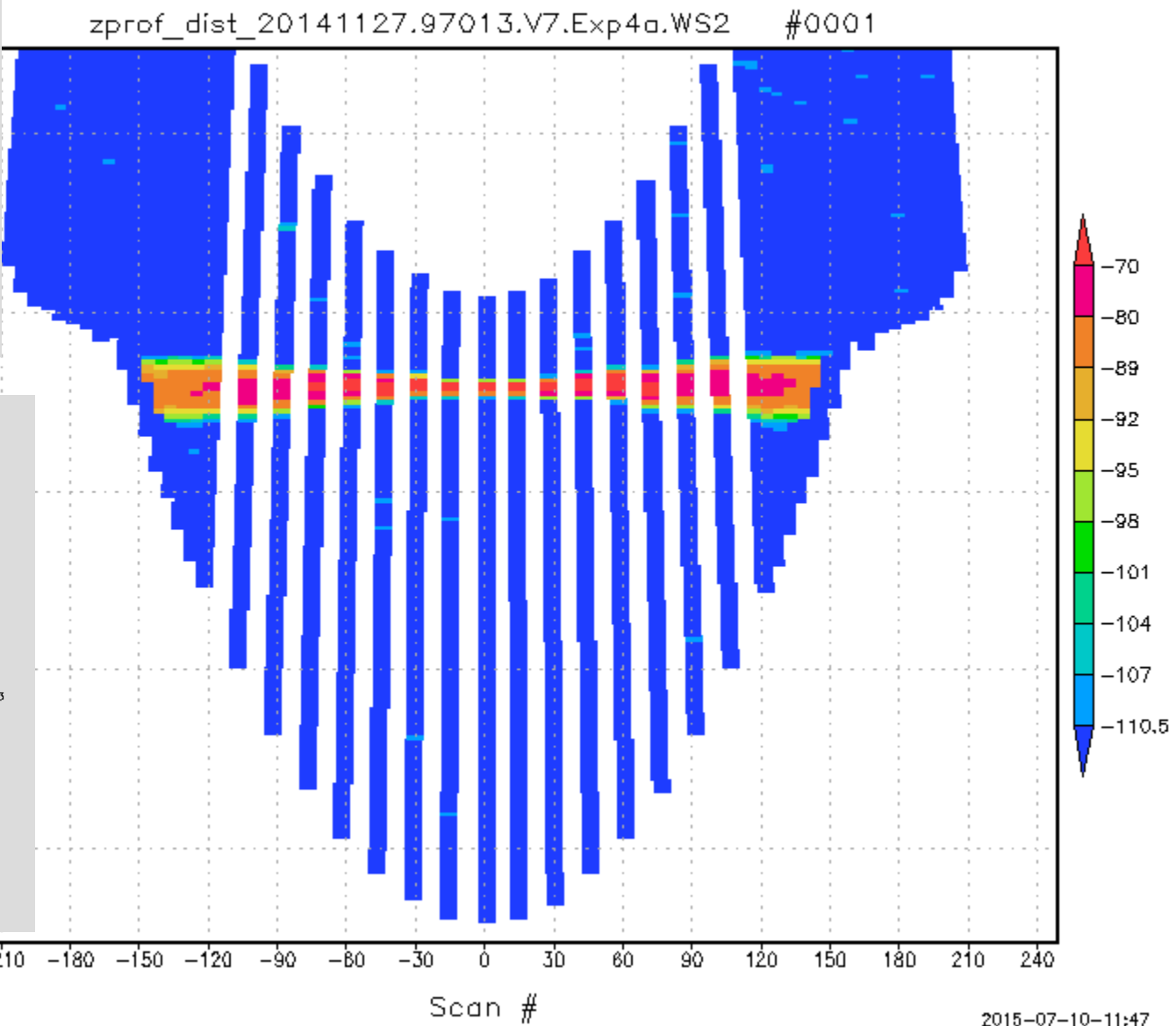
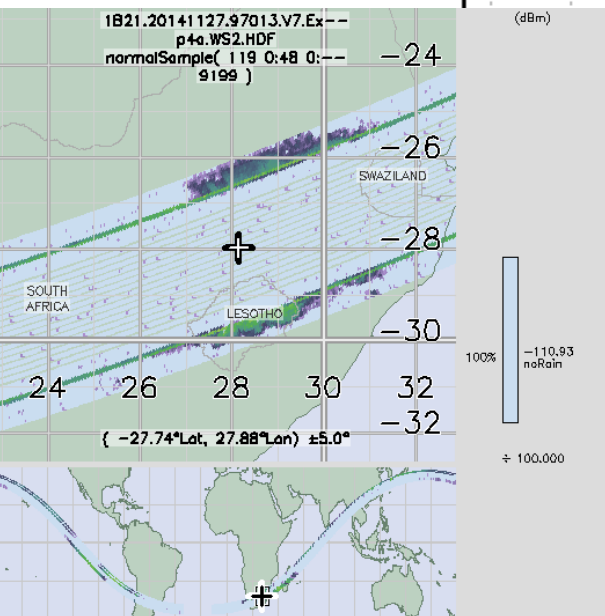
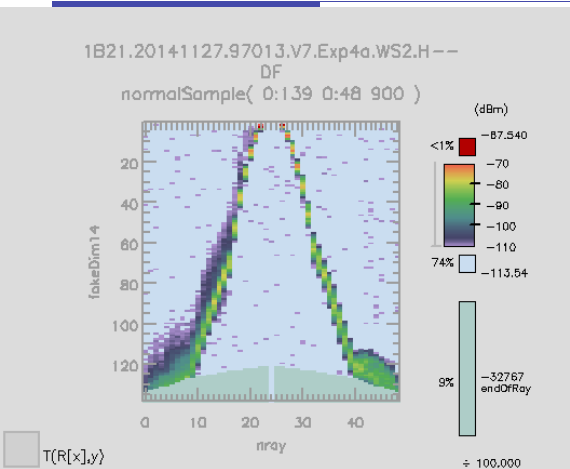


If the solar beta angle is less than 20 degrees, PR's operation was limited only day side of the orbit, because of battery issue.

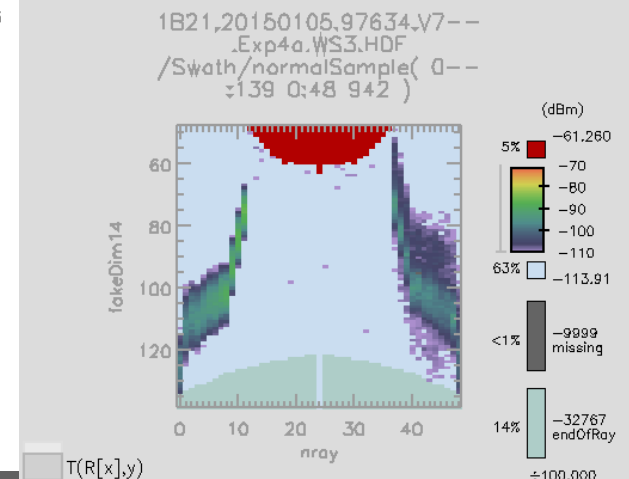
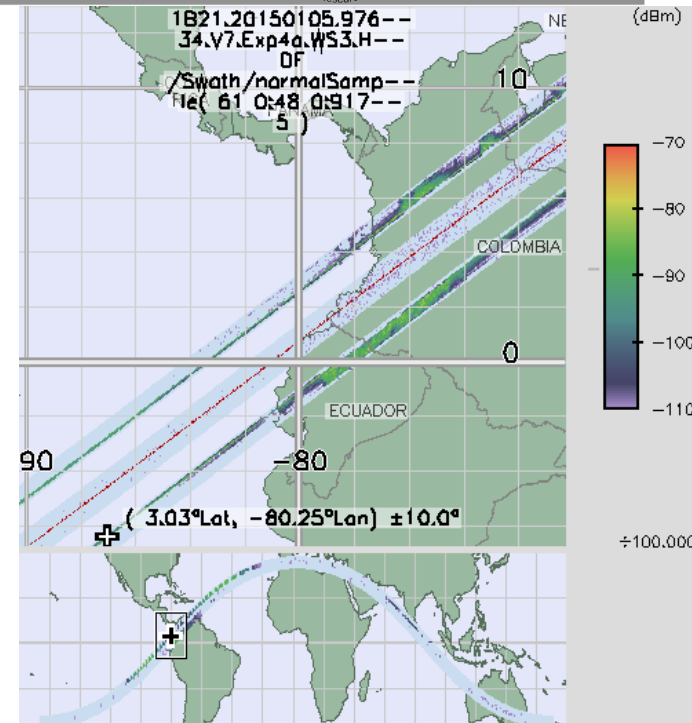
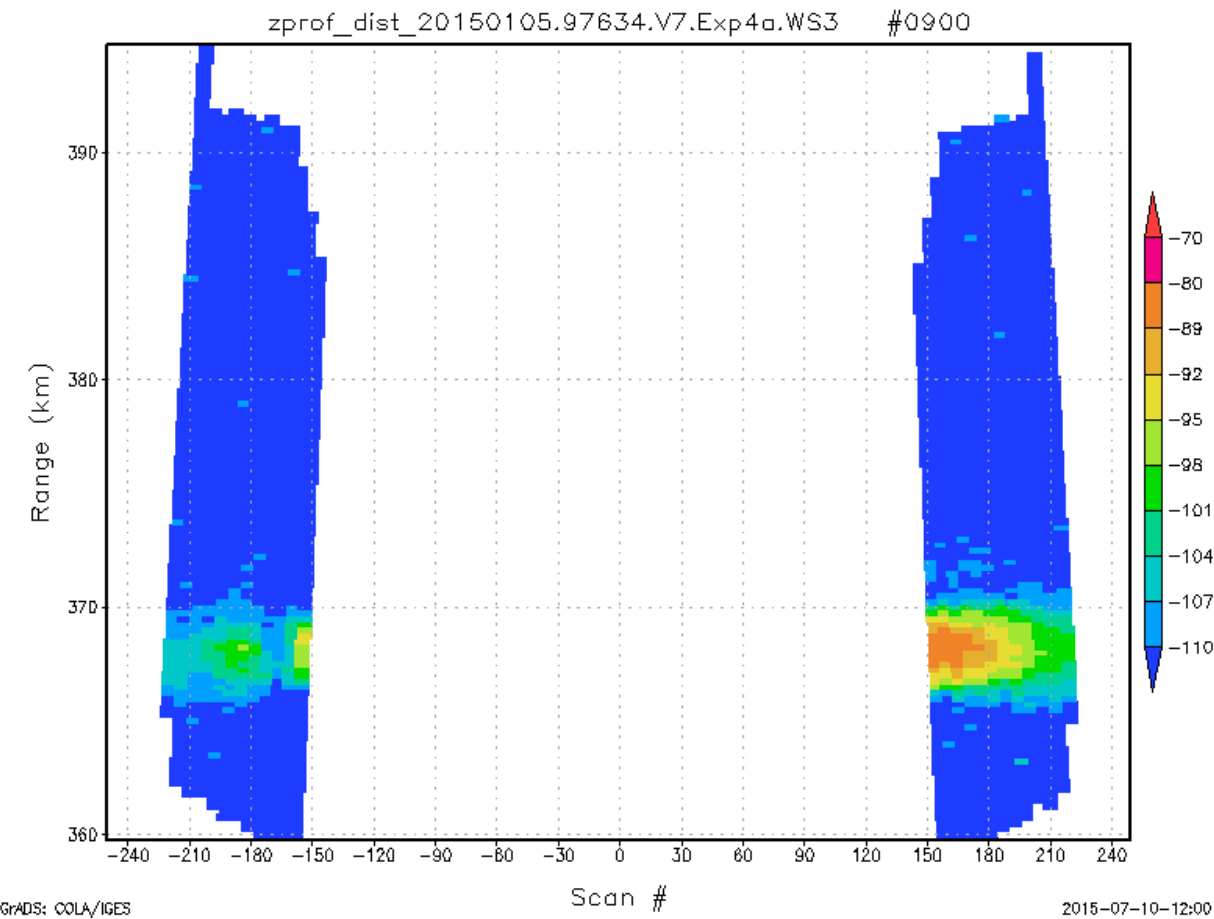
Wide swath -1 (swath width about 360 km)

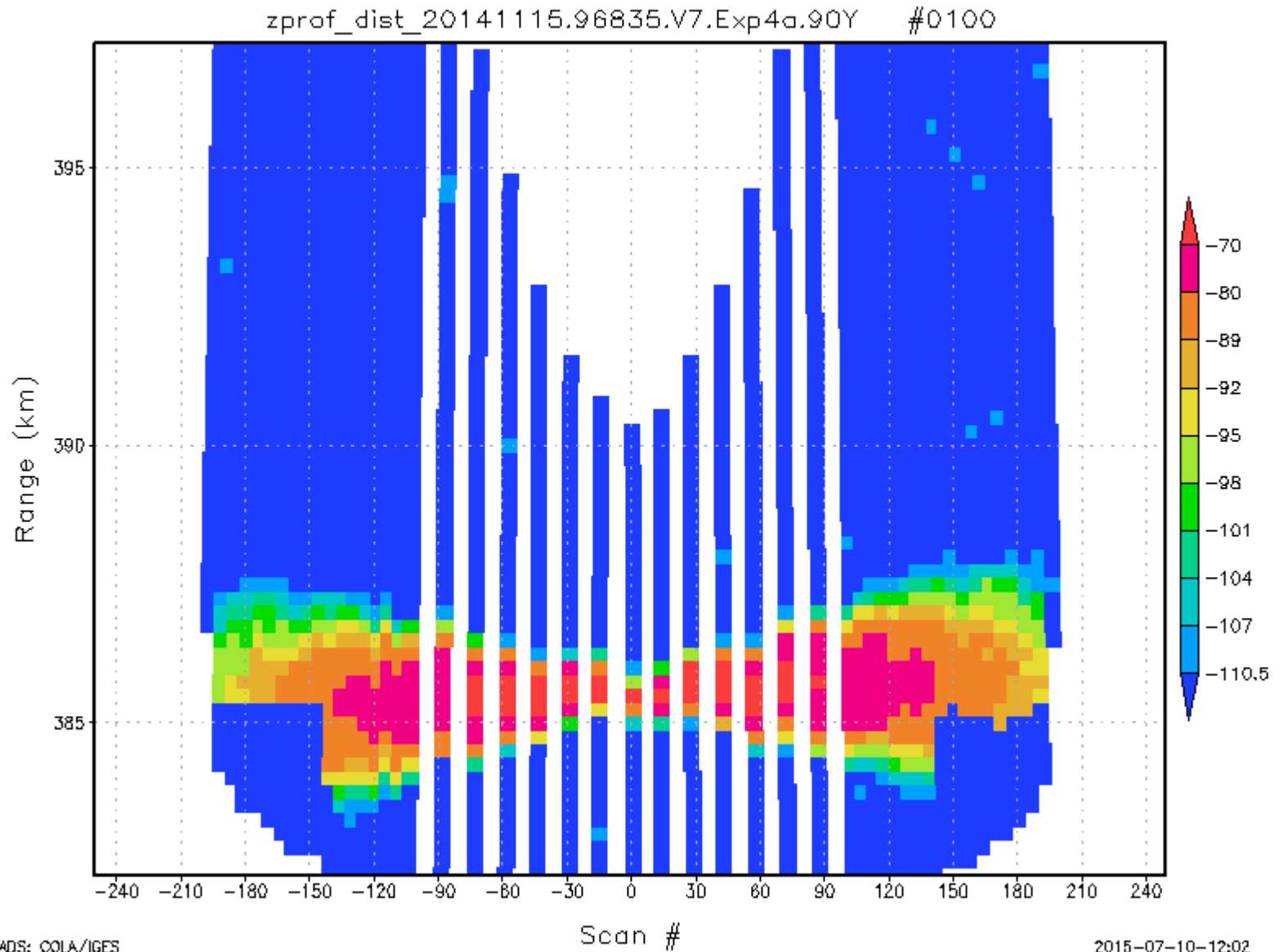
zprof_dist_20141031.96600.V7.Exp4a.WS1 #9100





Wide swath-3 (scan edge distance = about 450km)

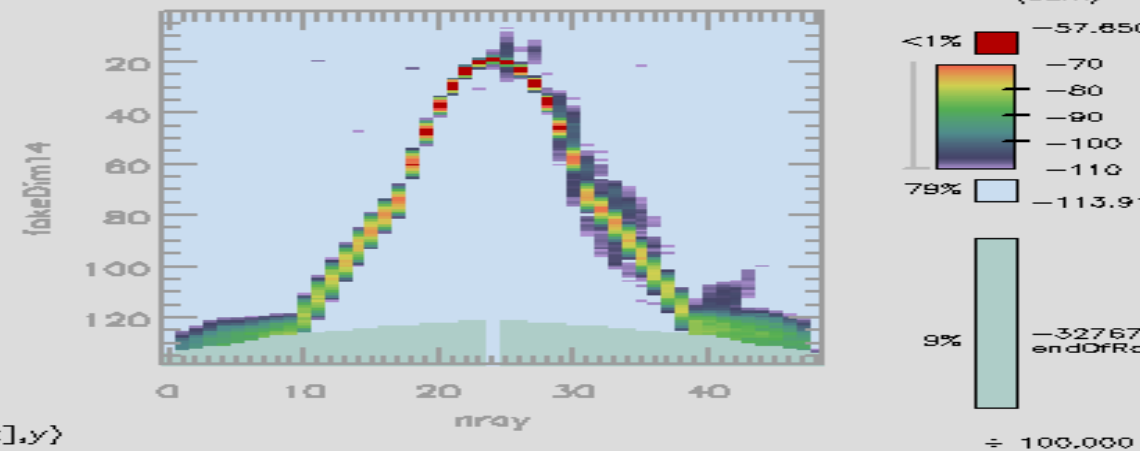




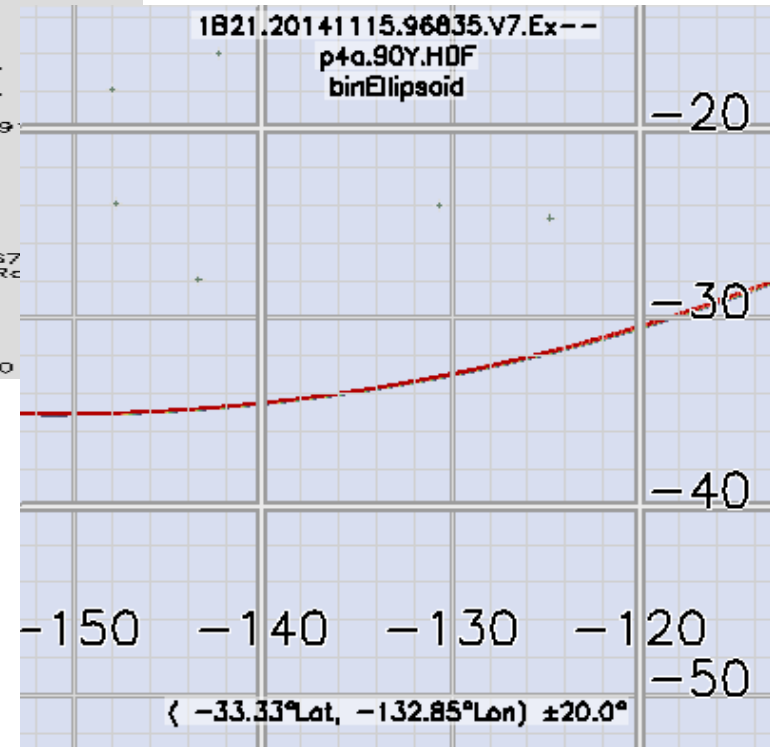
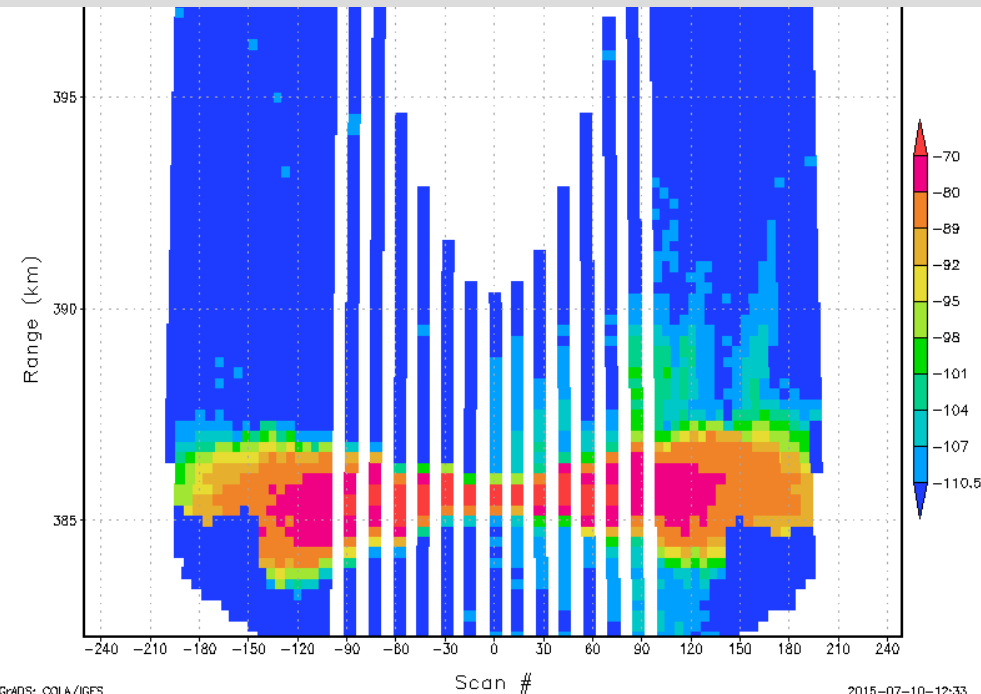
90-degree yaw experiment (frame by frame)

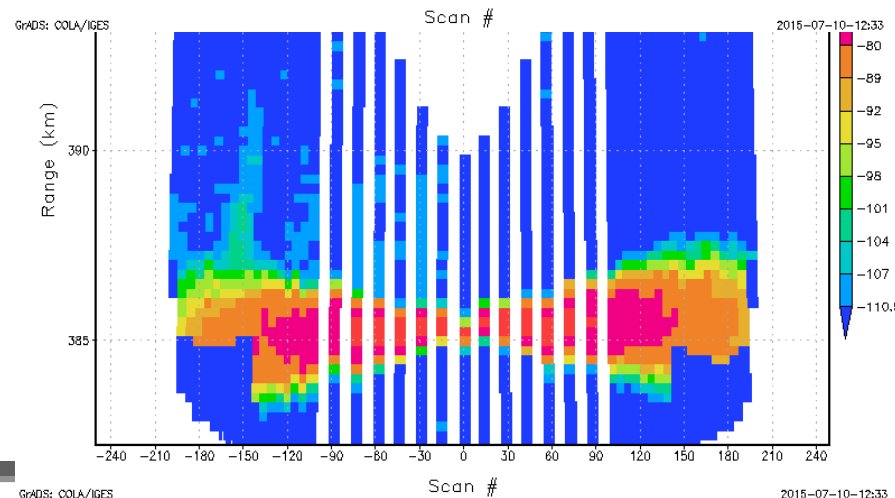
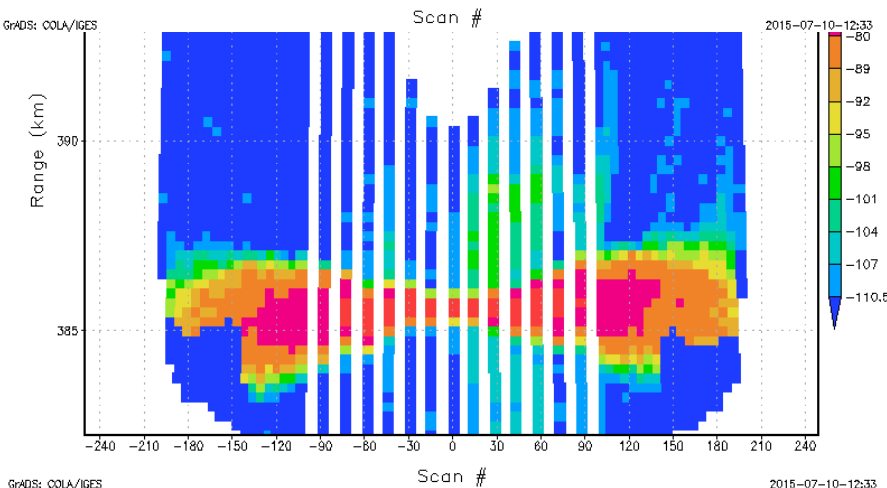
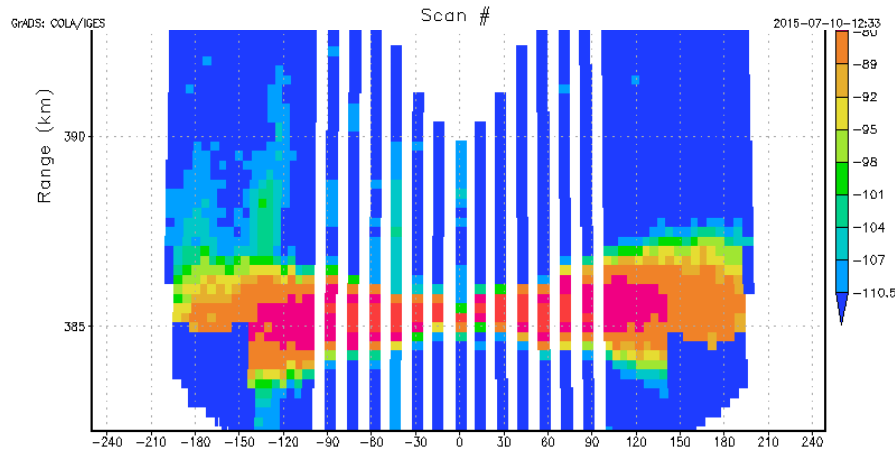
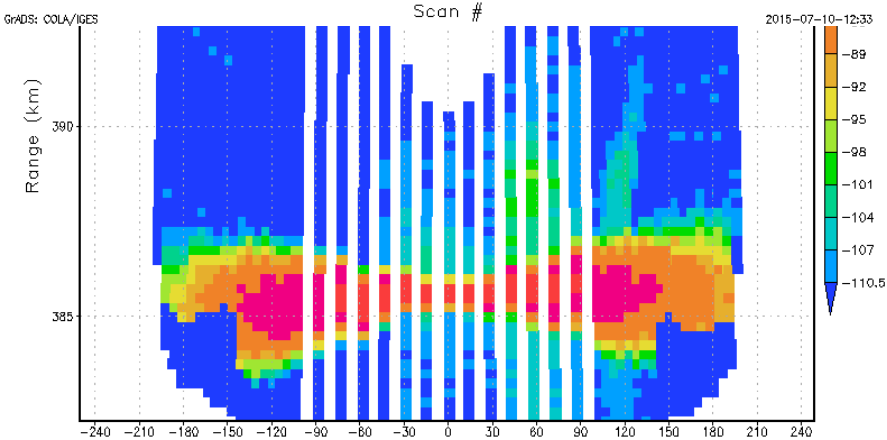
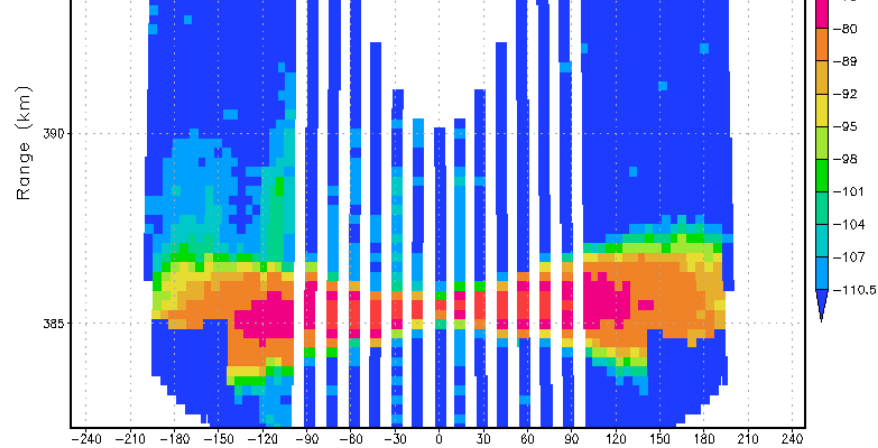
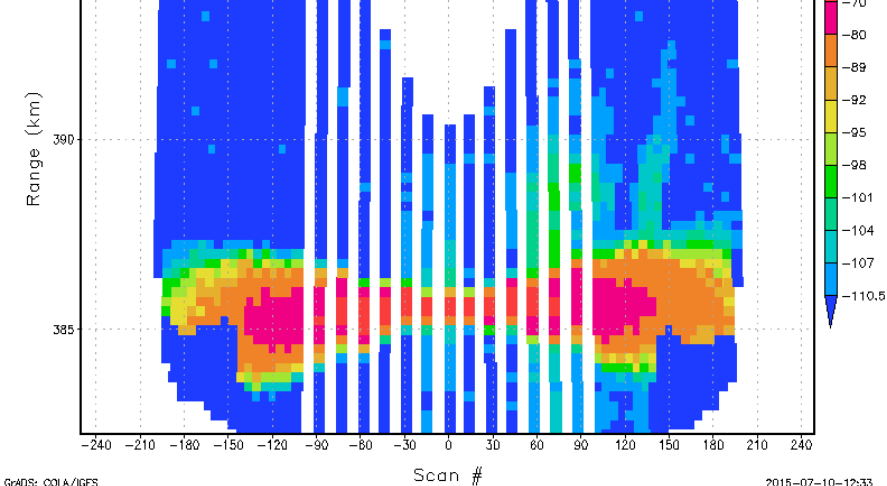
1B21.20141115.96835.V7.Exp4a.90Y.H--
DF

normalSample(0:139 0:48 160)



[.y]



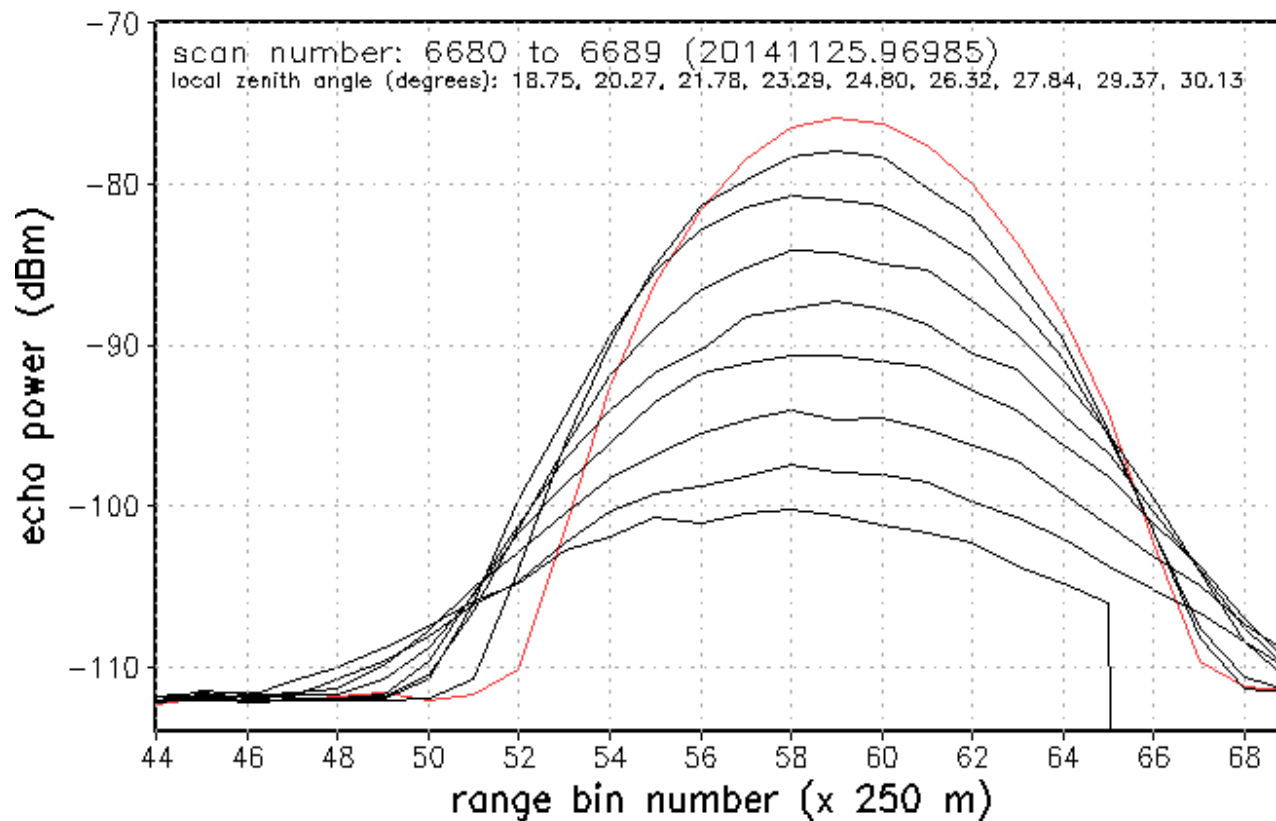


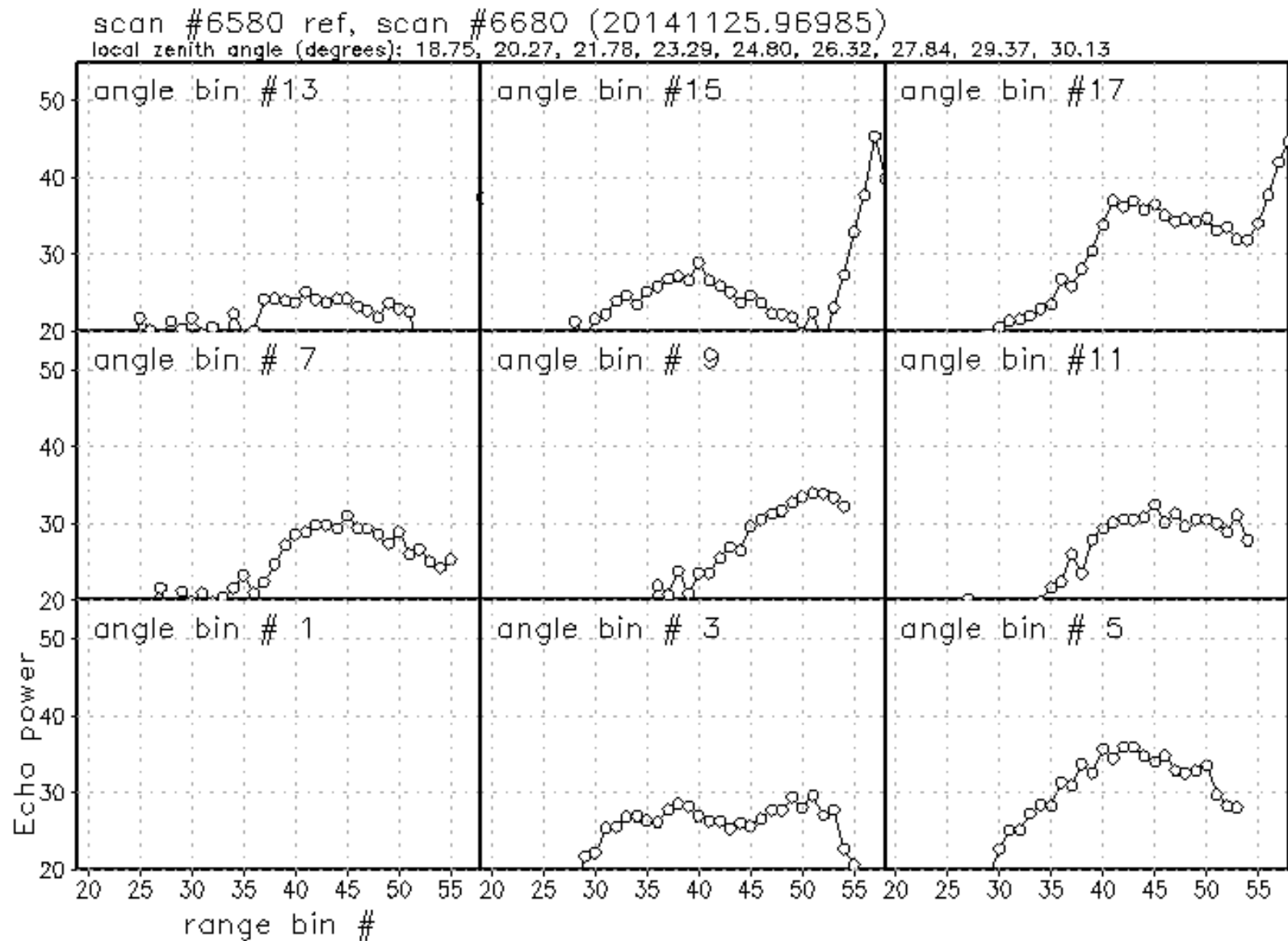
Averaged surface echo profile.

Red line corresponds to the scan edge profile of normal observation.

→clutter peak of 30 deg incident angle is more than 20 dB smaller than that of 18 deg incident angle. Several dB higher than the noise level.

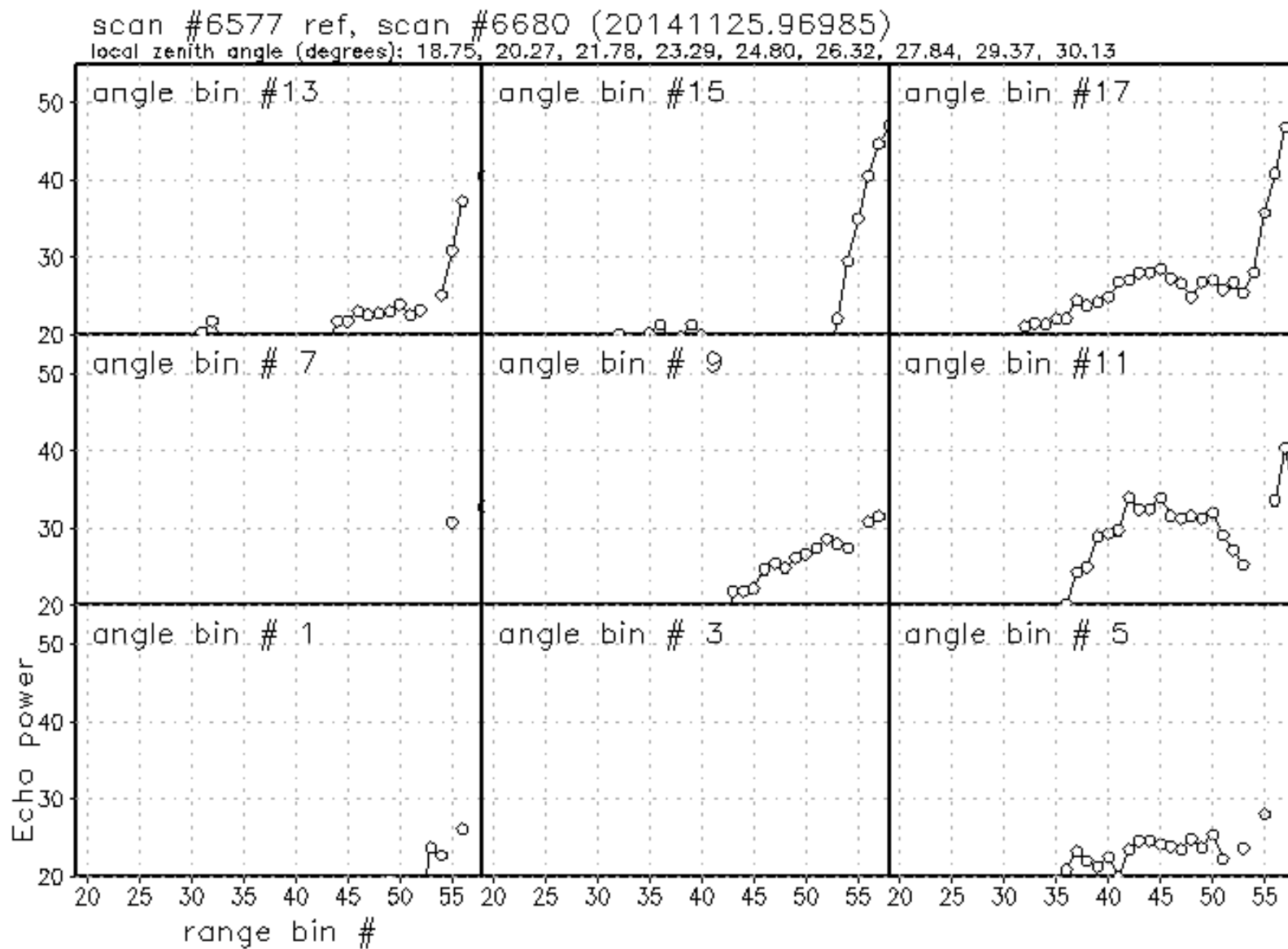
→wide swath data can be usable for moderate to heavy rainfall.





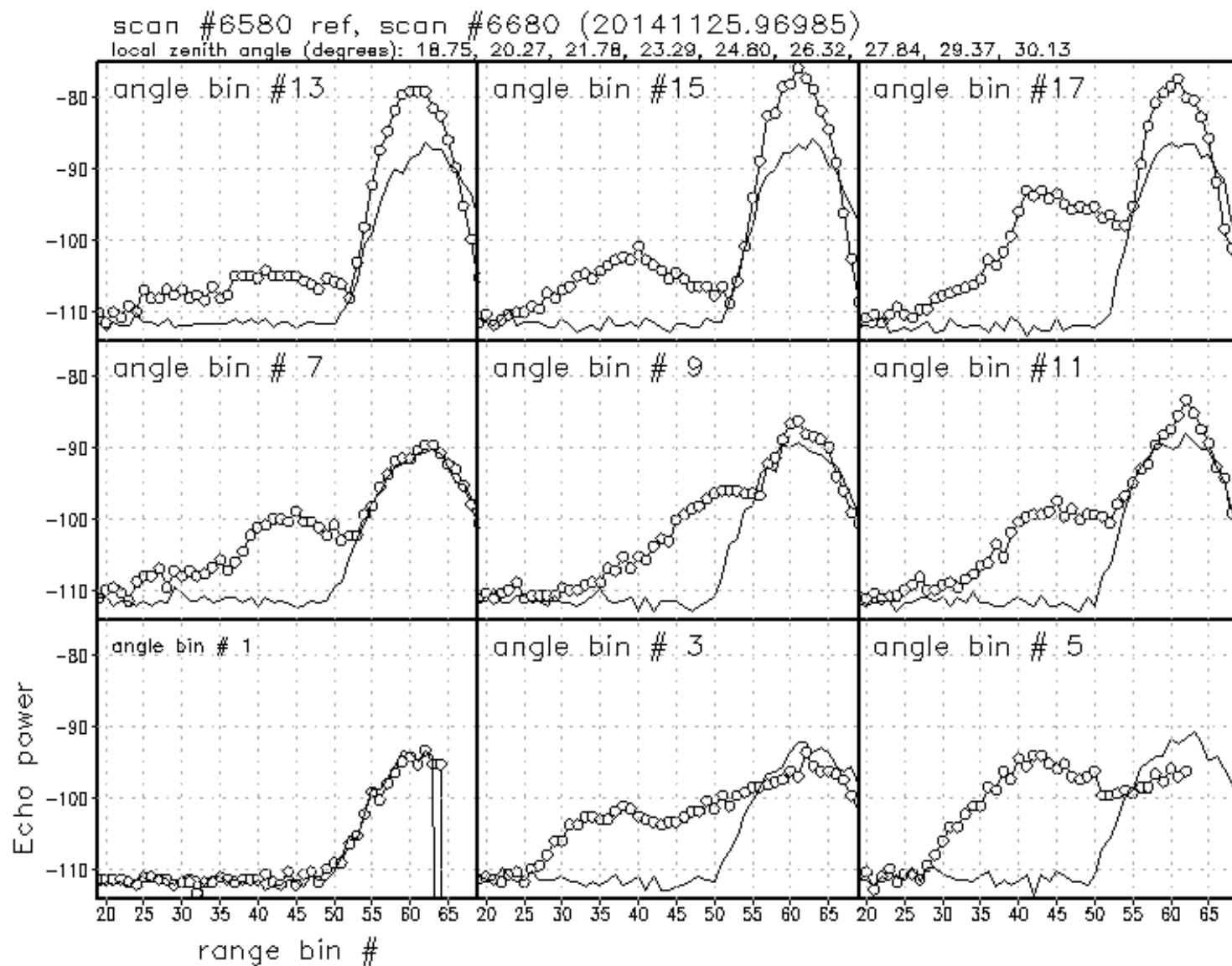


echo profile comparison (rain vs no-rain)

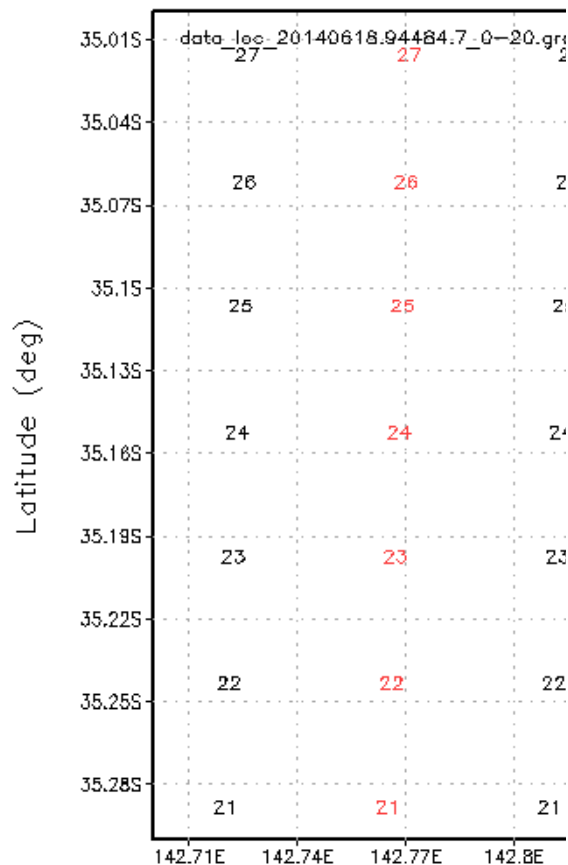




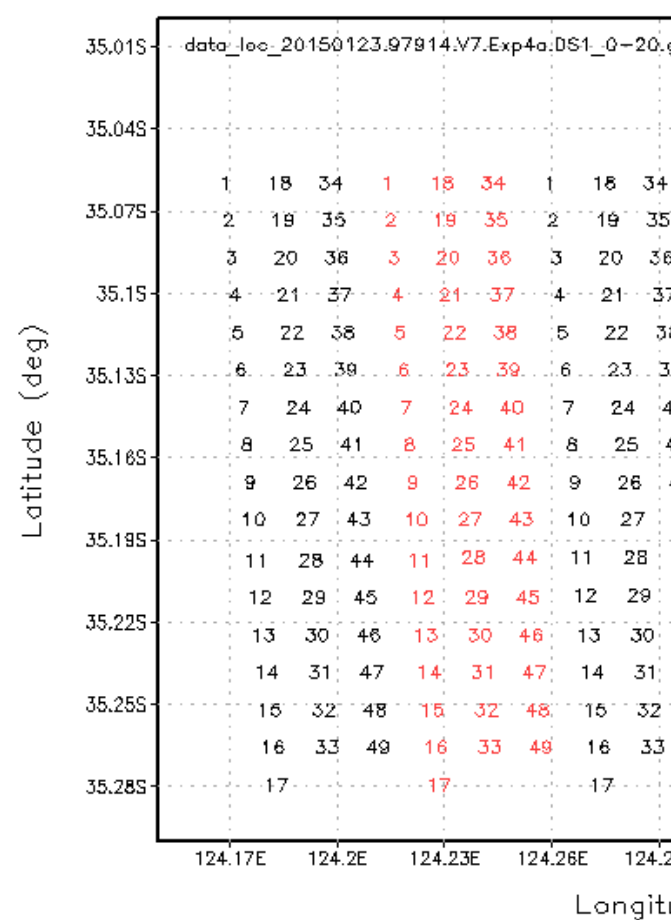
echo profile comparison (rain vs no-rain)



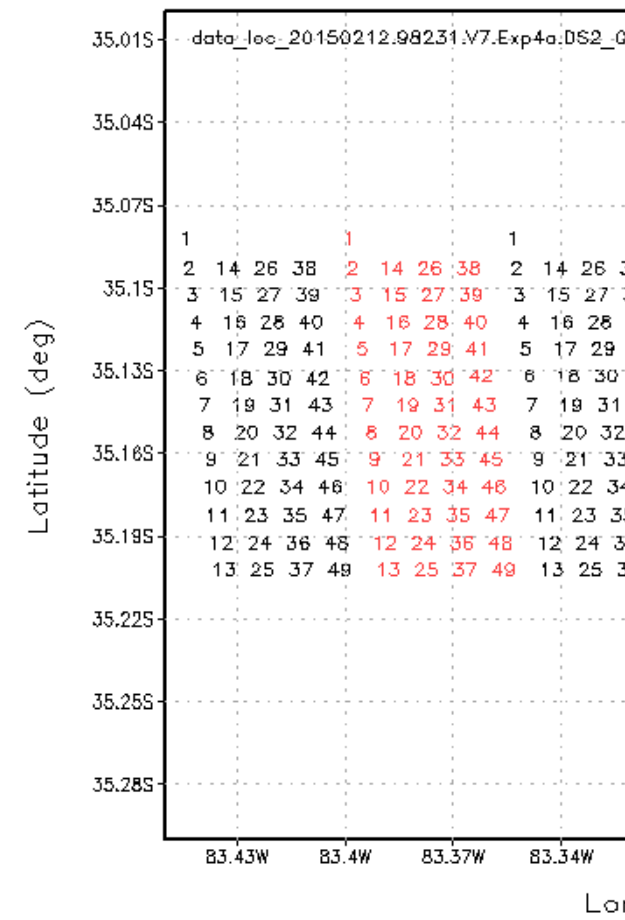
Normal



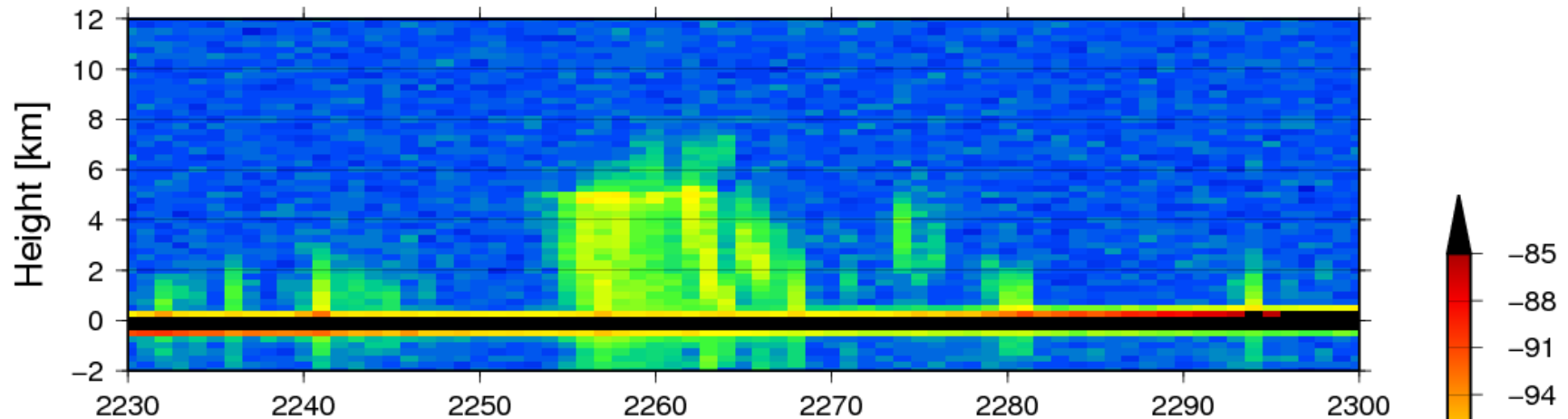
Dense (1/3)



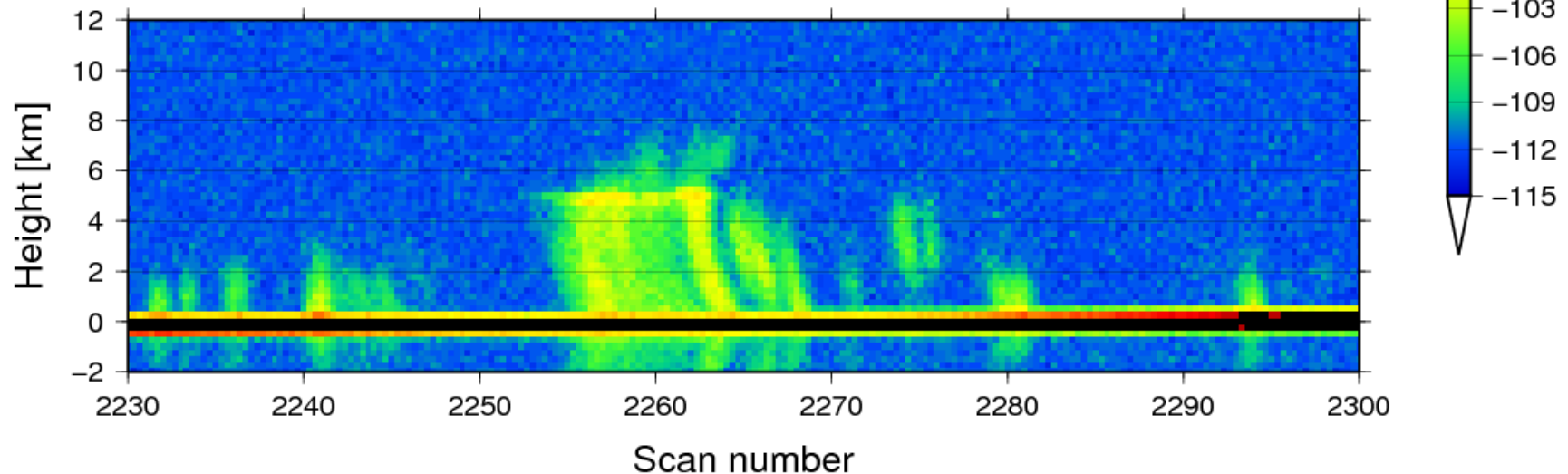
Dense (1/4)



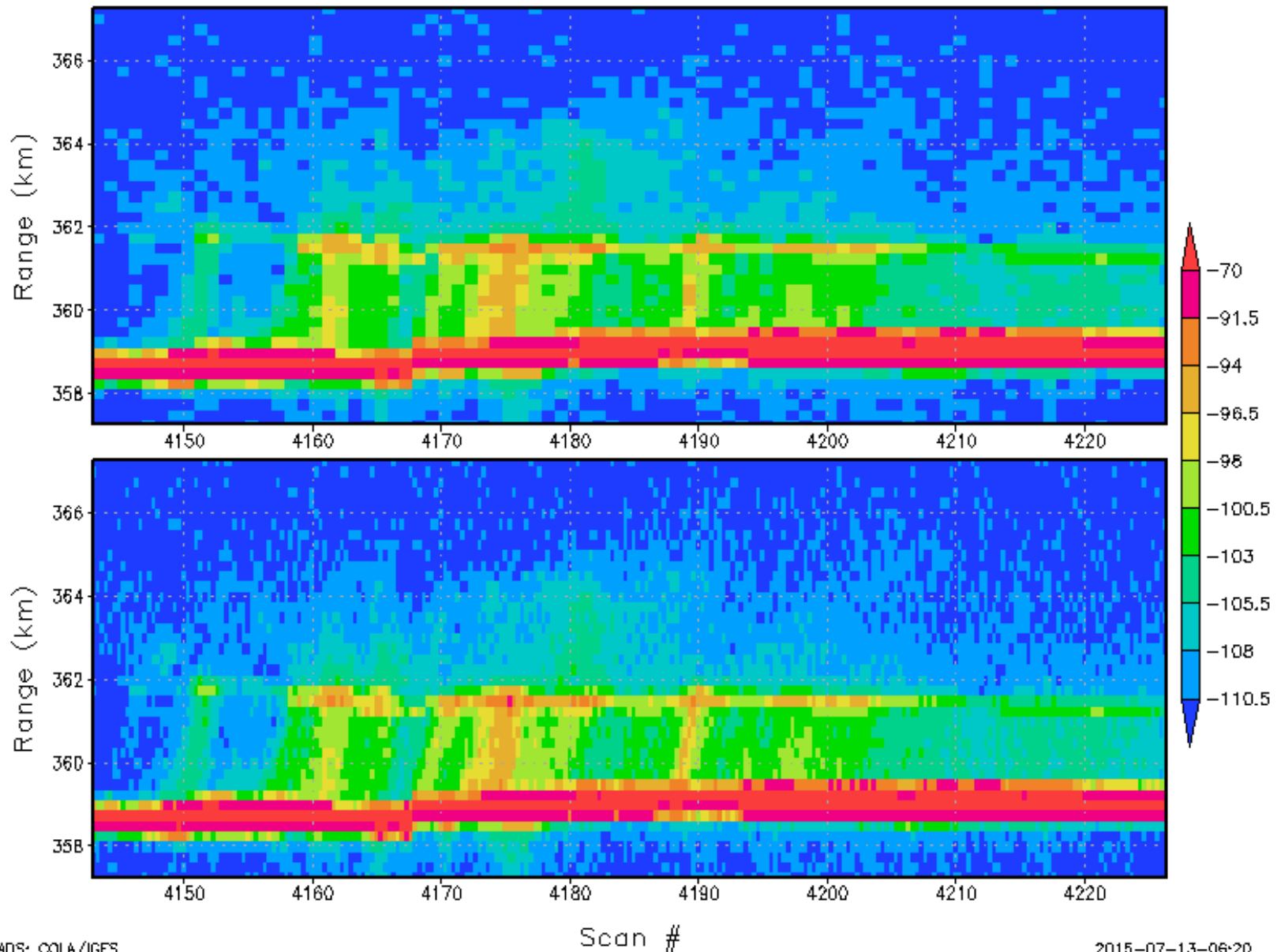
a) Normal sampling echo power [dBm]

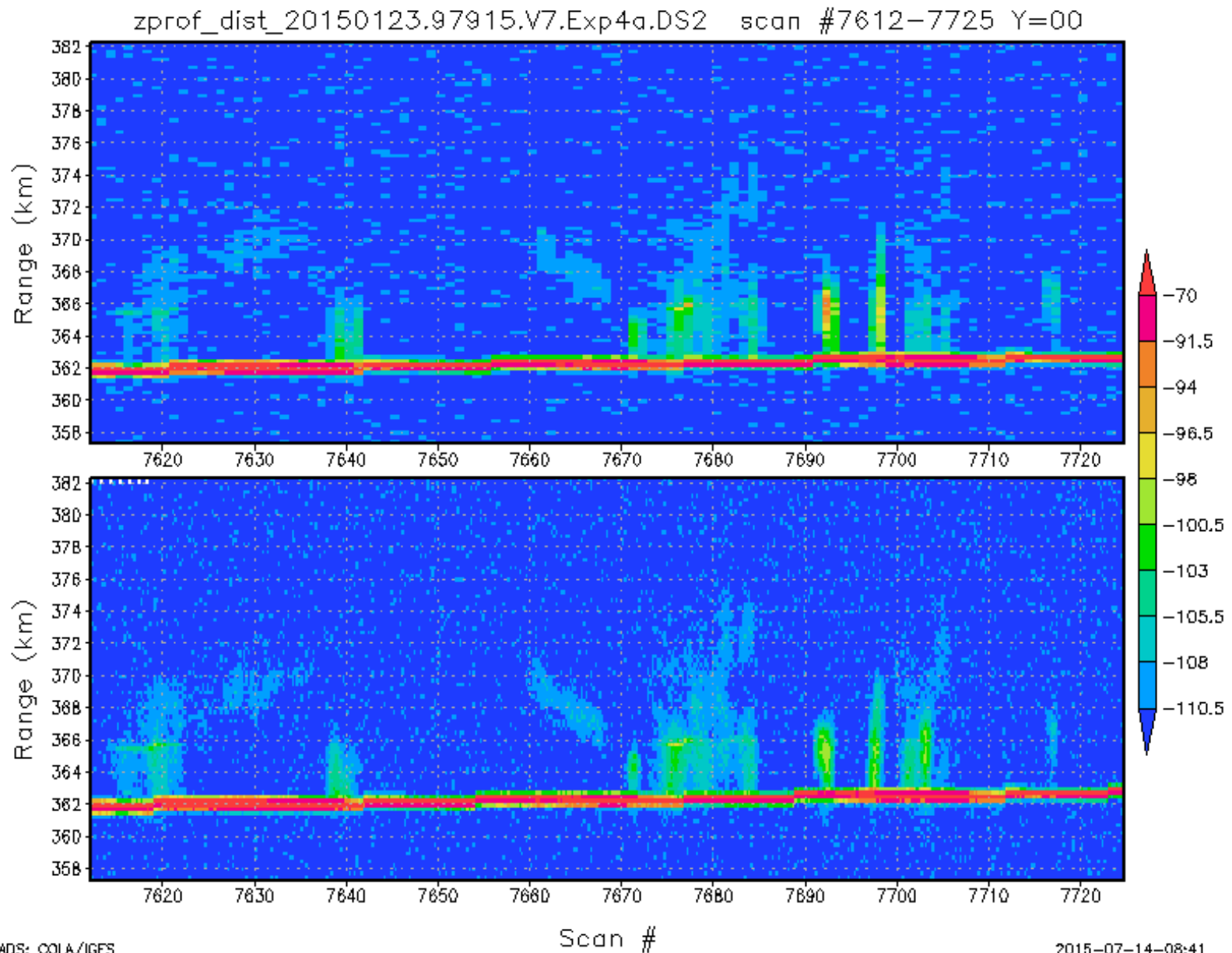


b) Dense sampling echo power [dBm]



zprof_dist_20150123.97914.V7.Exp4a.DS1 scan #4143-4227 Y=-5

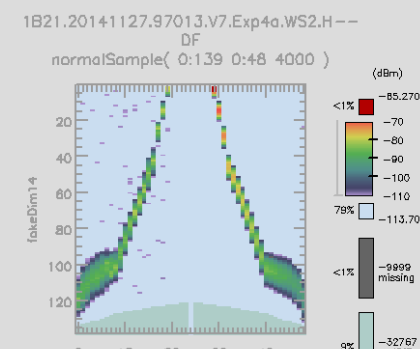
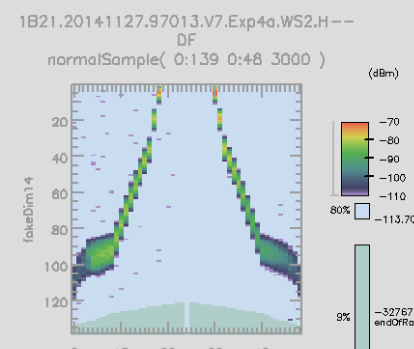
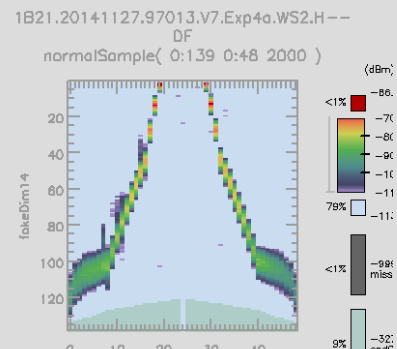
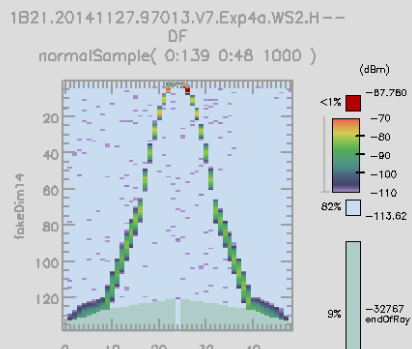
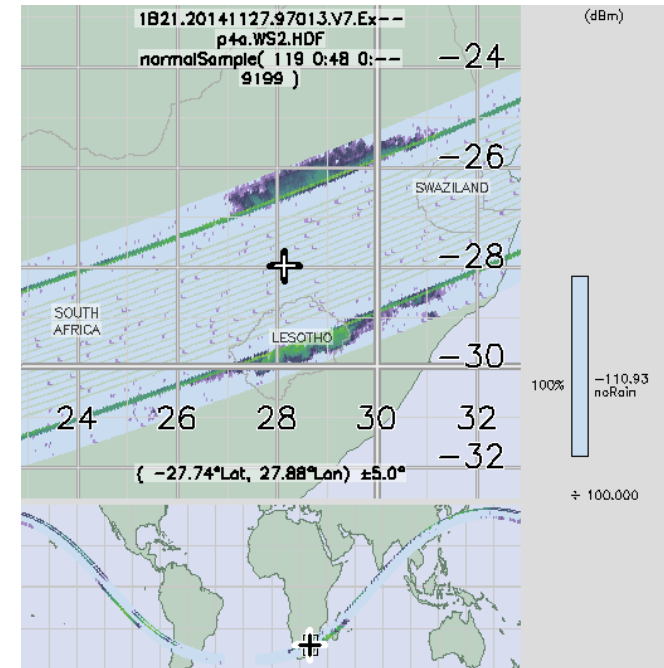
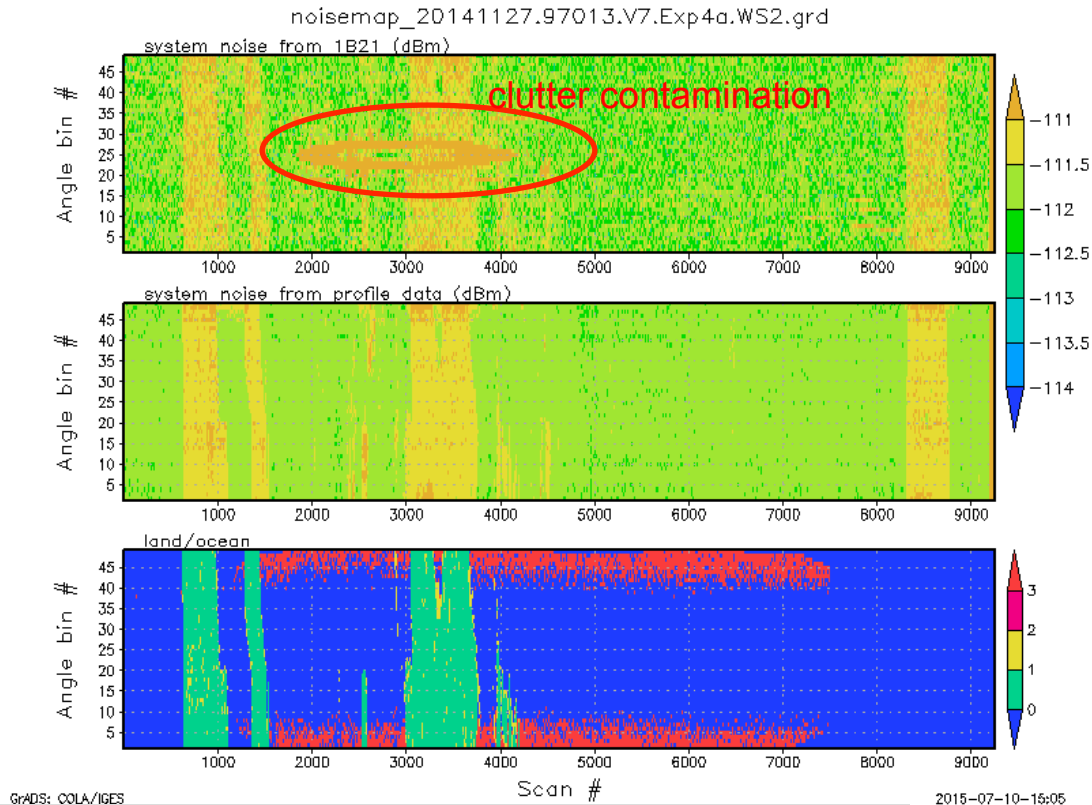






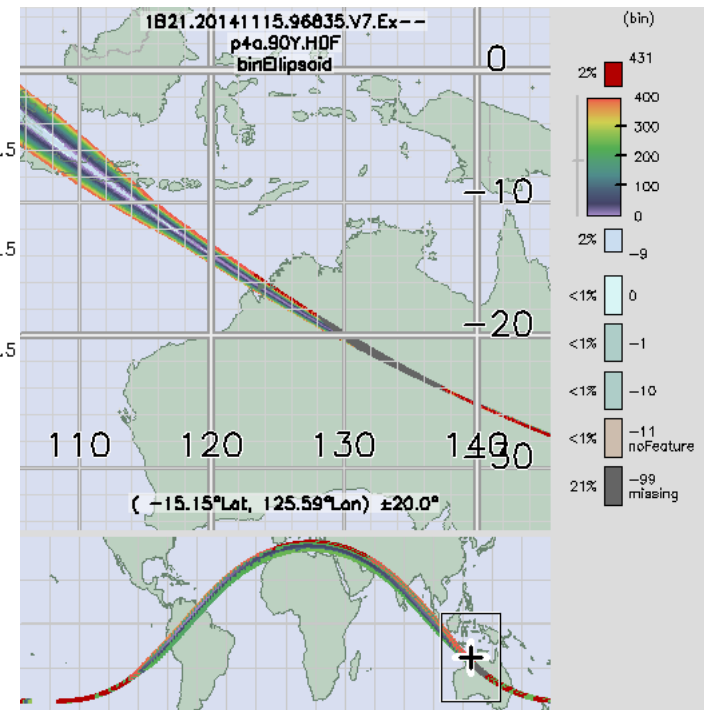
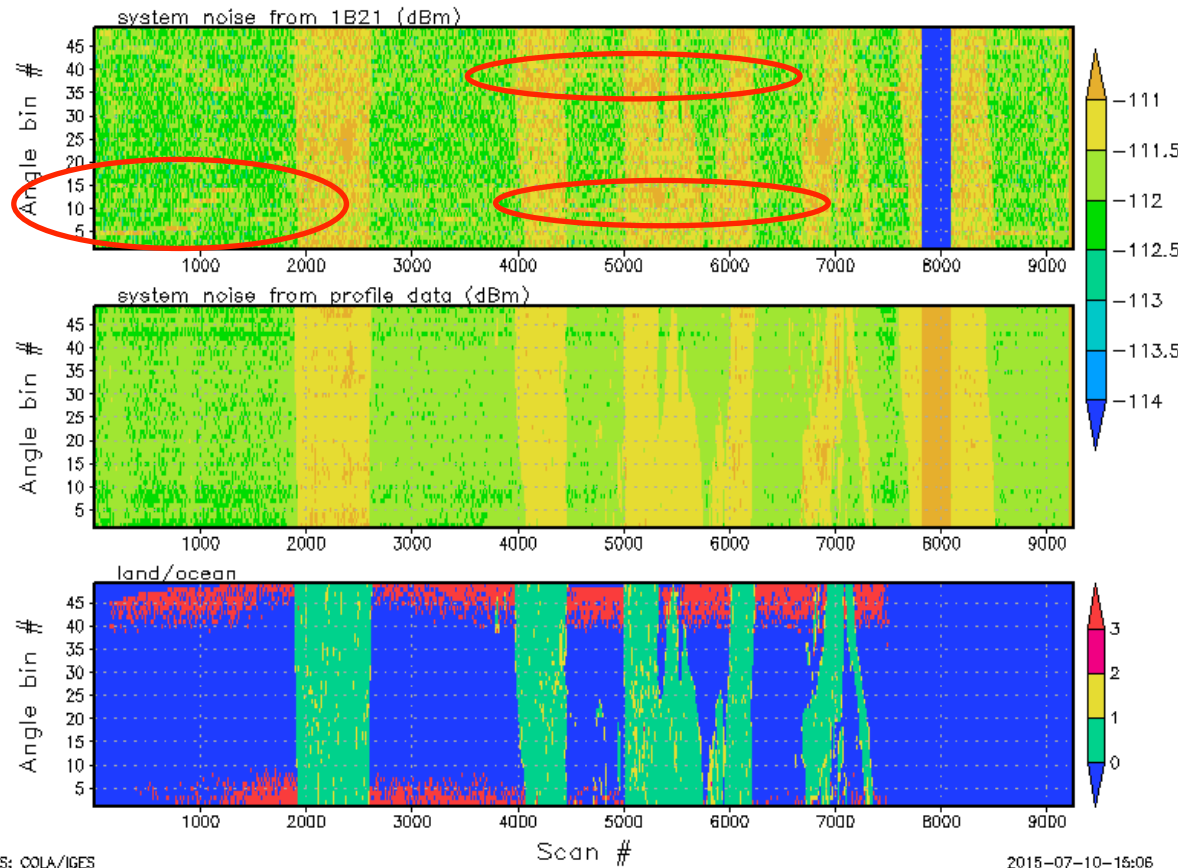
- parameters modified for special experiment:
 - geolocation (latitude, longitude), binEllipsoid, scLocalZenith
- parameters not modified for special experiment:
 - systemNoise, rain/no-rain flag, binSurfPeak, osBinStart, etc.
 - some parameters are not reliable.
- satellite attitude is also needed to be checked.

comparison between normal noise sample data (top) and no-rain echo average (middle)

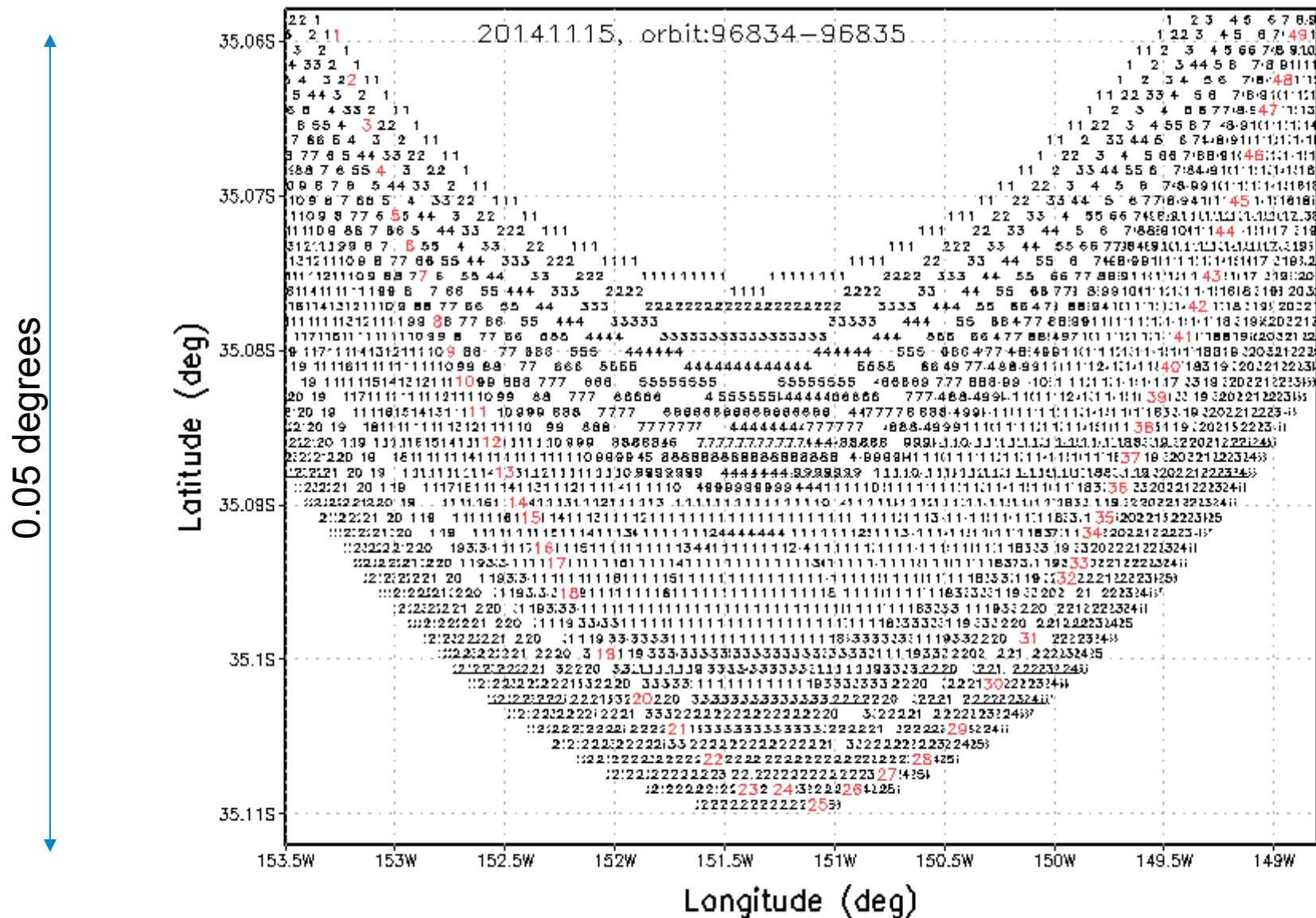


System noise evaluation (90Y case)

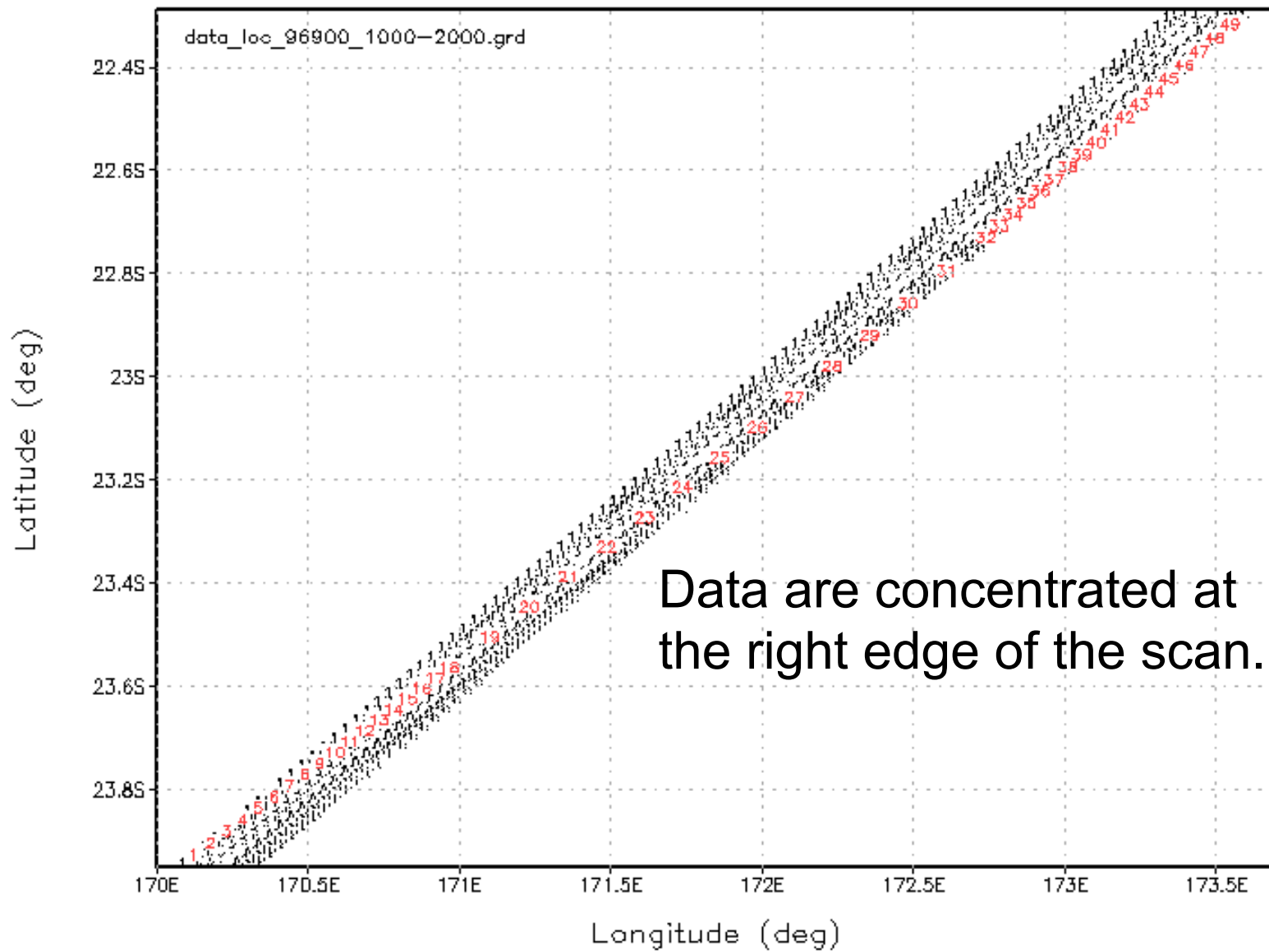
noisemap_20141115.96835.grd

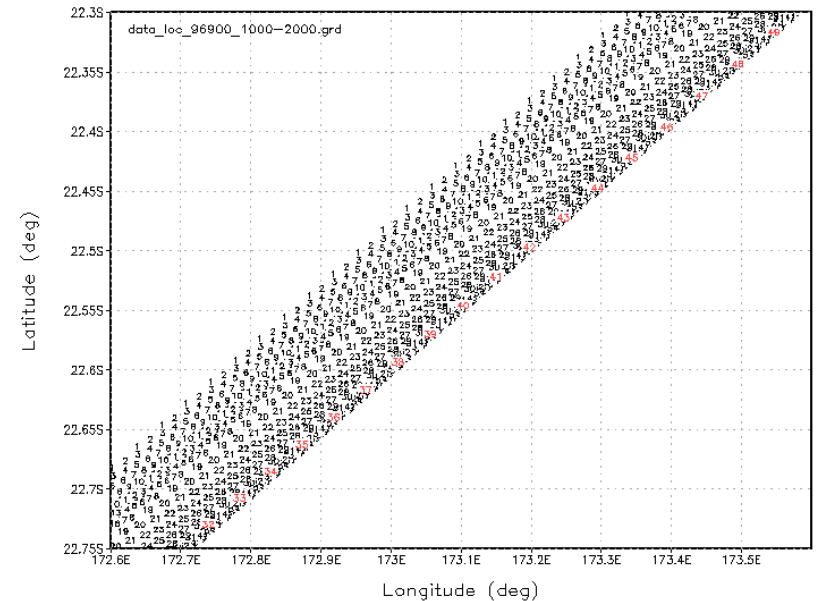
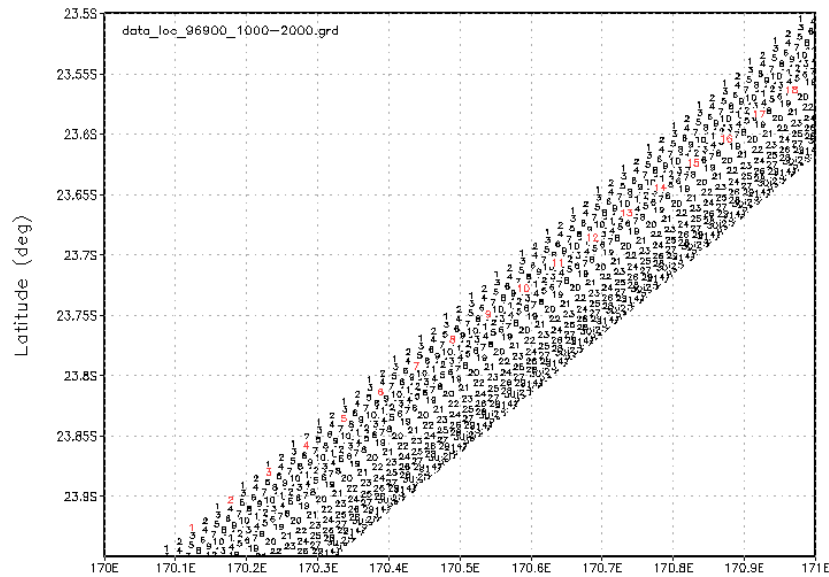


footprint trajectory (90Y) @35S



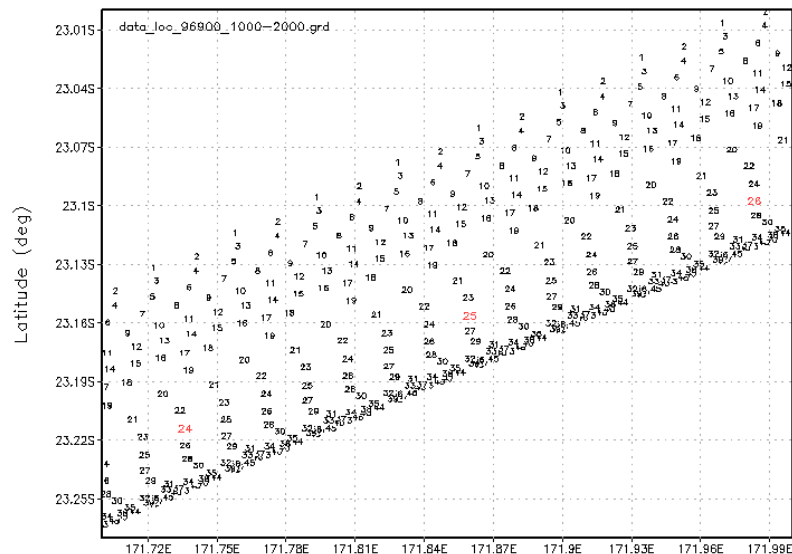
4.5 degrees





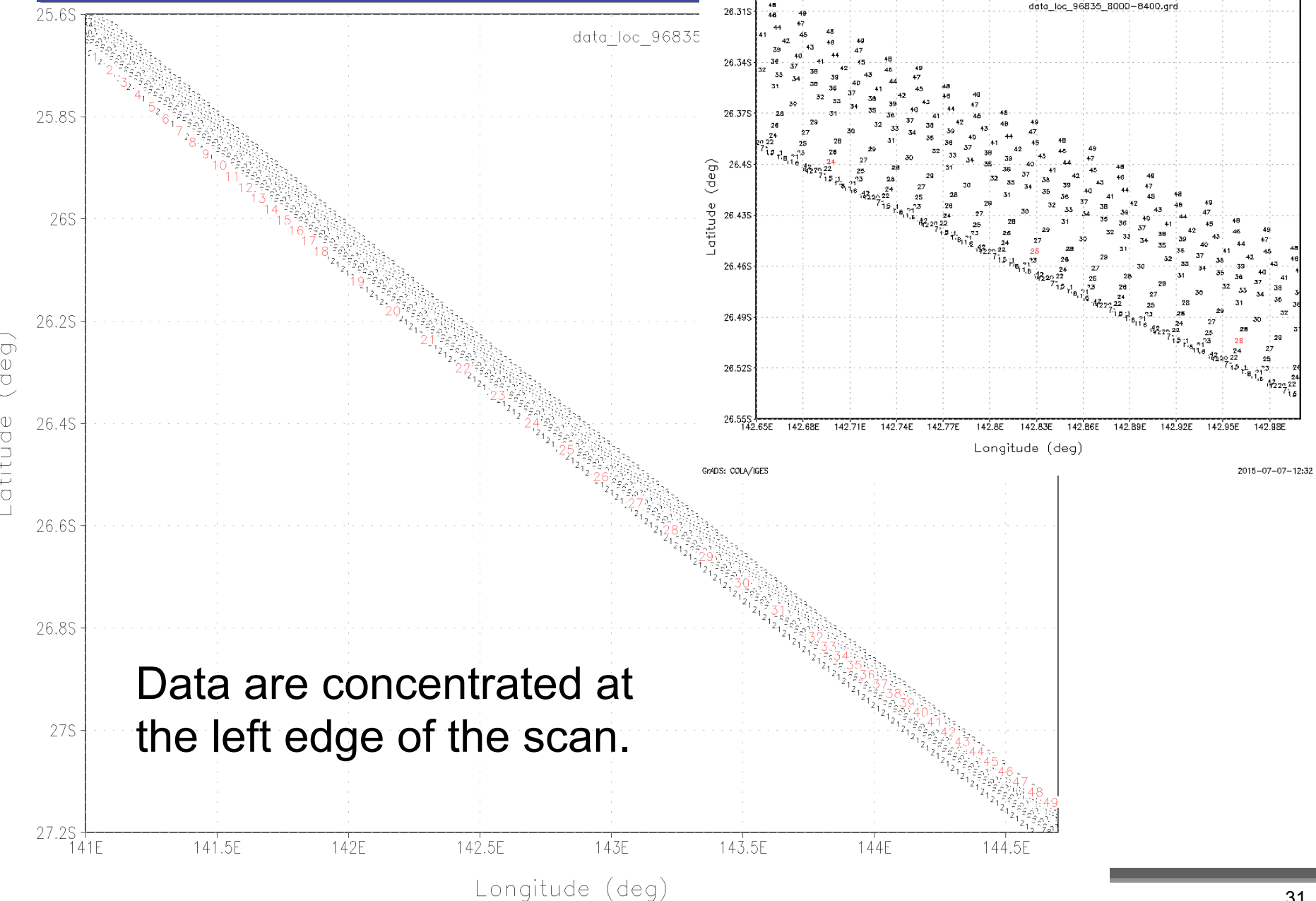
GrADS: COLA/IGES

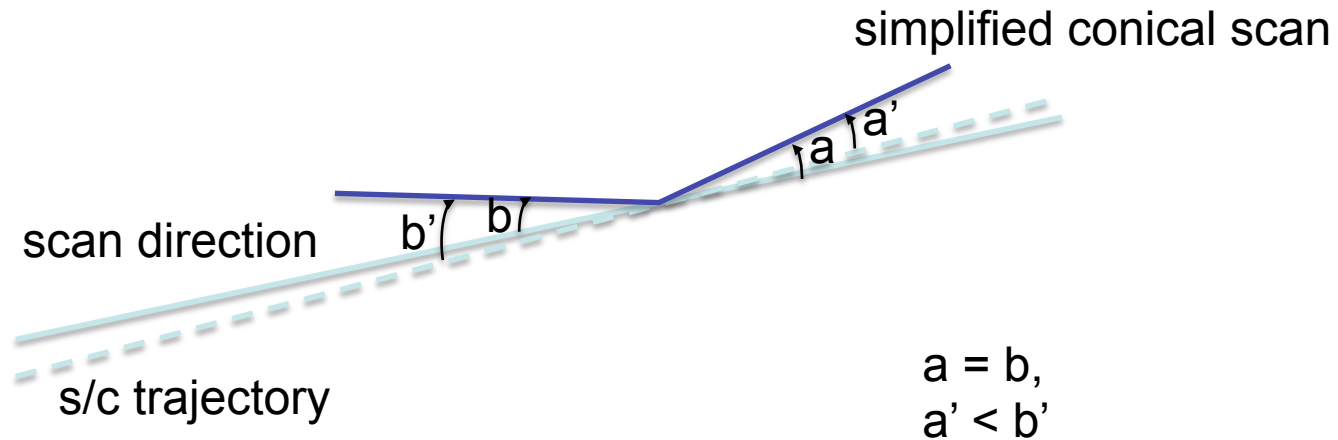
2015-07-07-11:18



Footprints from later half of scan are concentrated at right edge. It is caused by the effect of the earth rotation and the PR's conical scan.

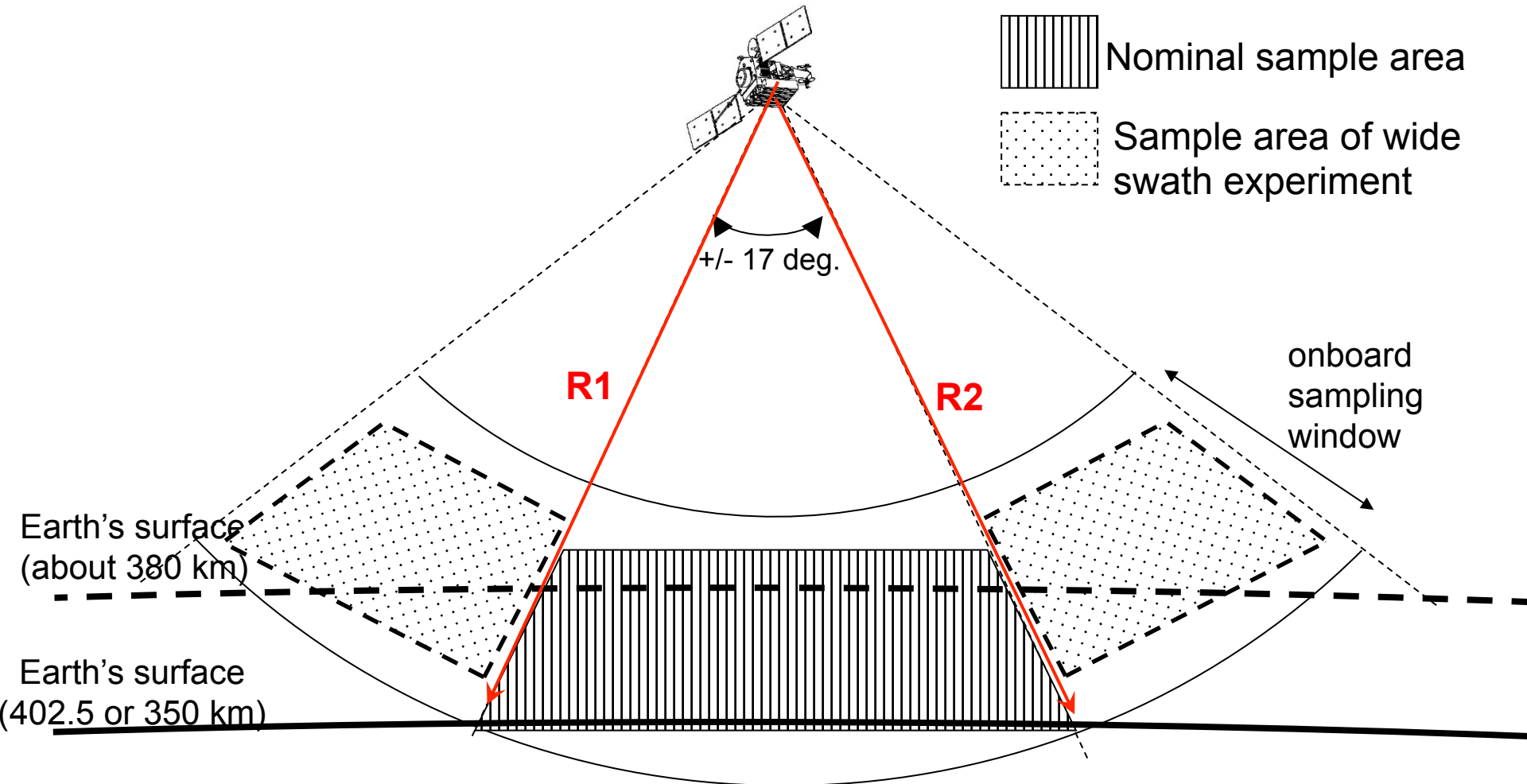
Footprint trajectory (descending, 90Y)





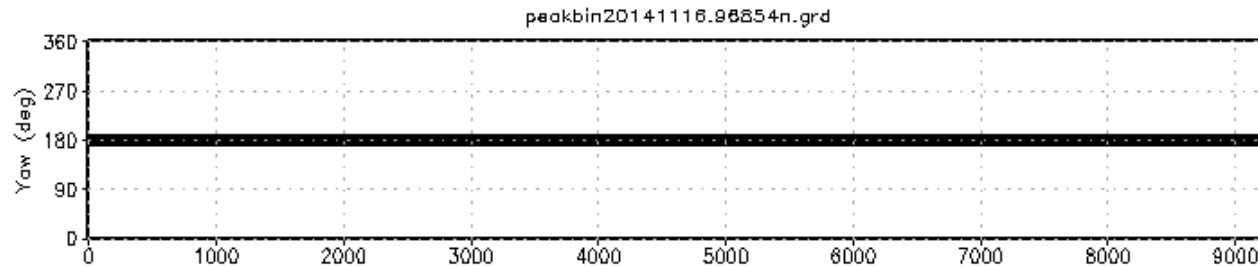
if a' (b') is zero, the footprints of various incident angle will be overlapped.

- Spacecraft roll can be estimated by using the surface echo distance of opposite direction. ($R1 - R2$)
- In the case of 90Y, $R1-R2$ represents the pitch offset.



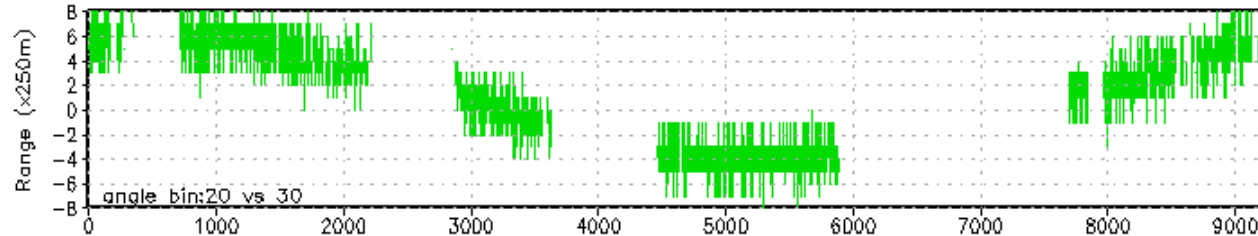
- Sinusoidal change of roll angle was seen during the orbit boot in 2001.
- It indicates the spacecraft roll adjustment did not work when the satellite altitude is between 350 and 402 km.

Yaw



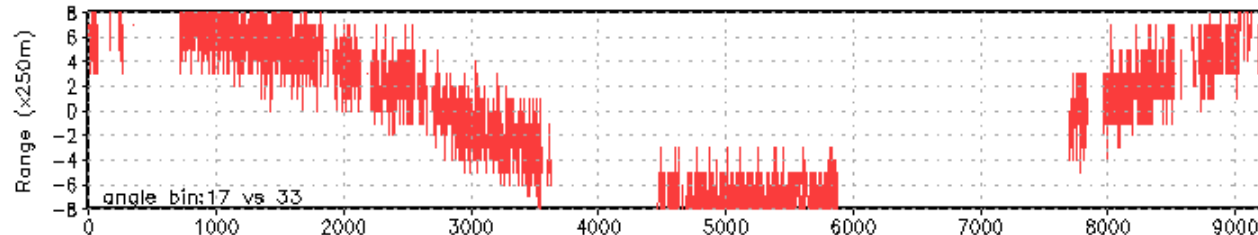
R1 - R2

(angle bin 20 vs 30)



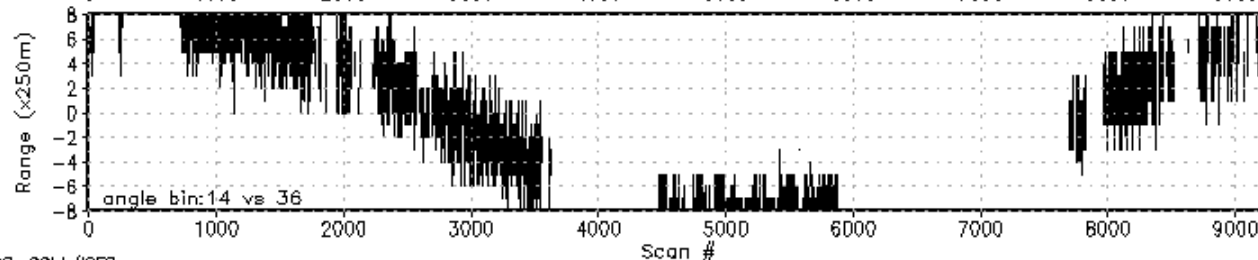
R1 - R2

(angle bin 17 vs 33)

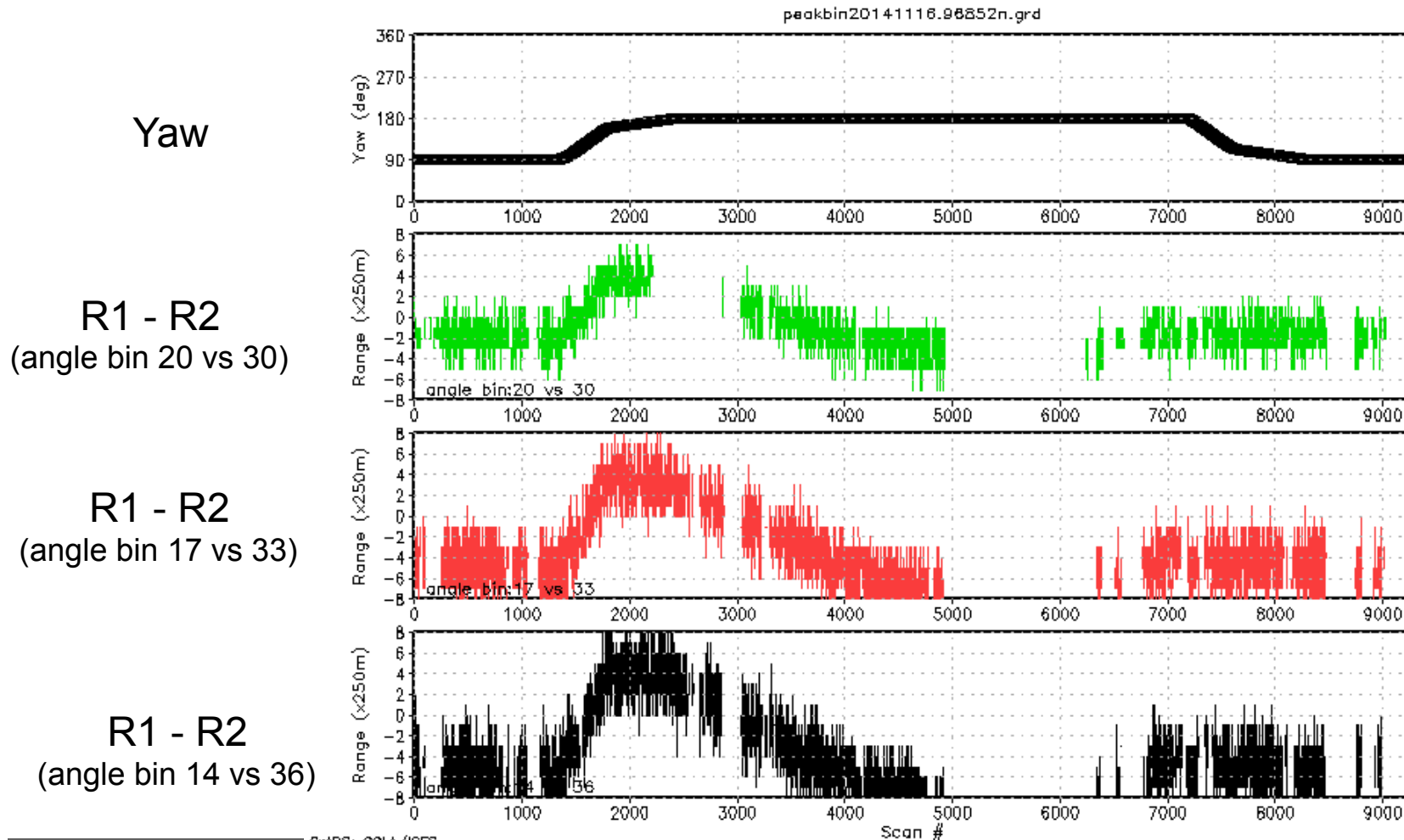


R1 - R2

(angle bin 14 vs 36)



- When the yaw angle is 90 degrees, R1-R2 moves to the negative bias.

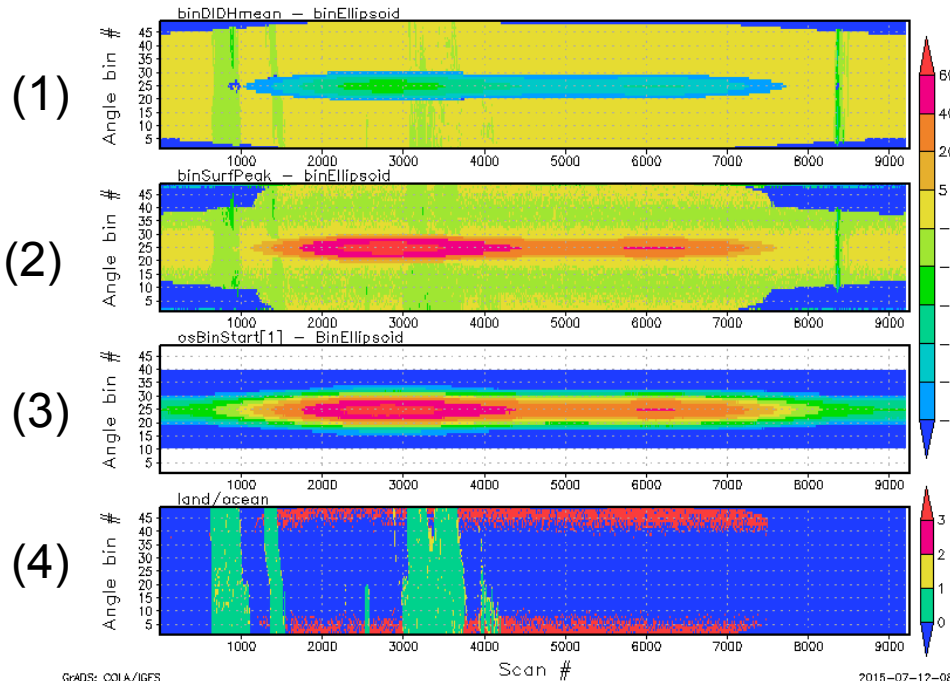


- (1) binSurfPeak – binEllipsoid
- (2) binDIDHmean – binEllipsoid
- (3) osBinStart - binEllipsoid
- (4) land/ocean flag

binEllipsoid is correctly updated for special experiments. binSurfPeak and osBinStart are depends on the onboard surface detection algorithm that assumes normal observation geometry.

wide swath 2 (Nov. 27, 2014)

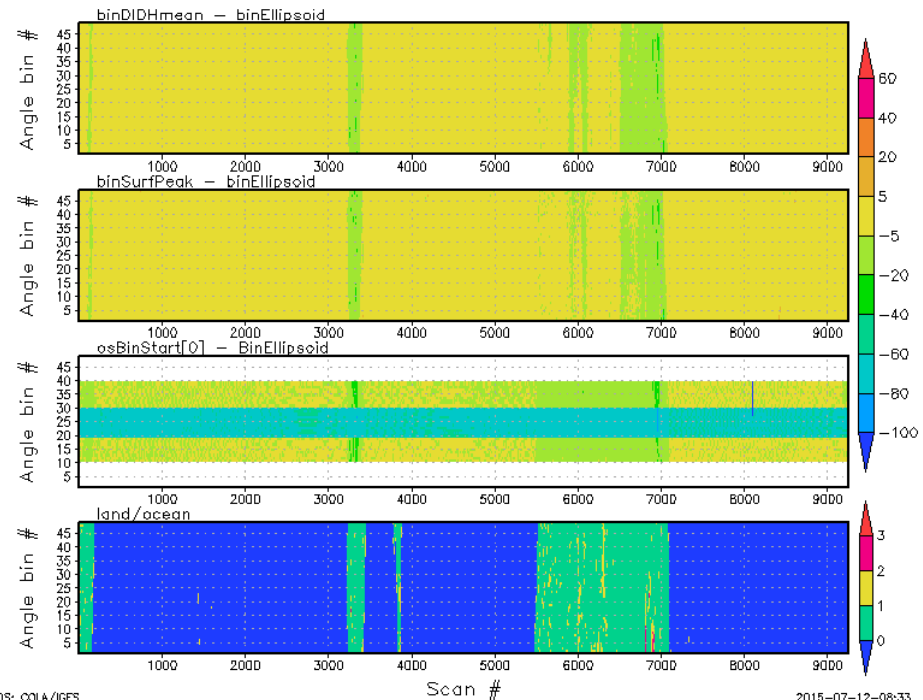
rangebincmp_20141127.97013.V7.Exp4a.WS2.grd



GRADS: COLA/IGES

normal obs. (June 18, 2014)

rangebincmp_20140618.94484.7.grd

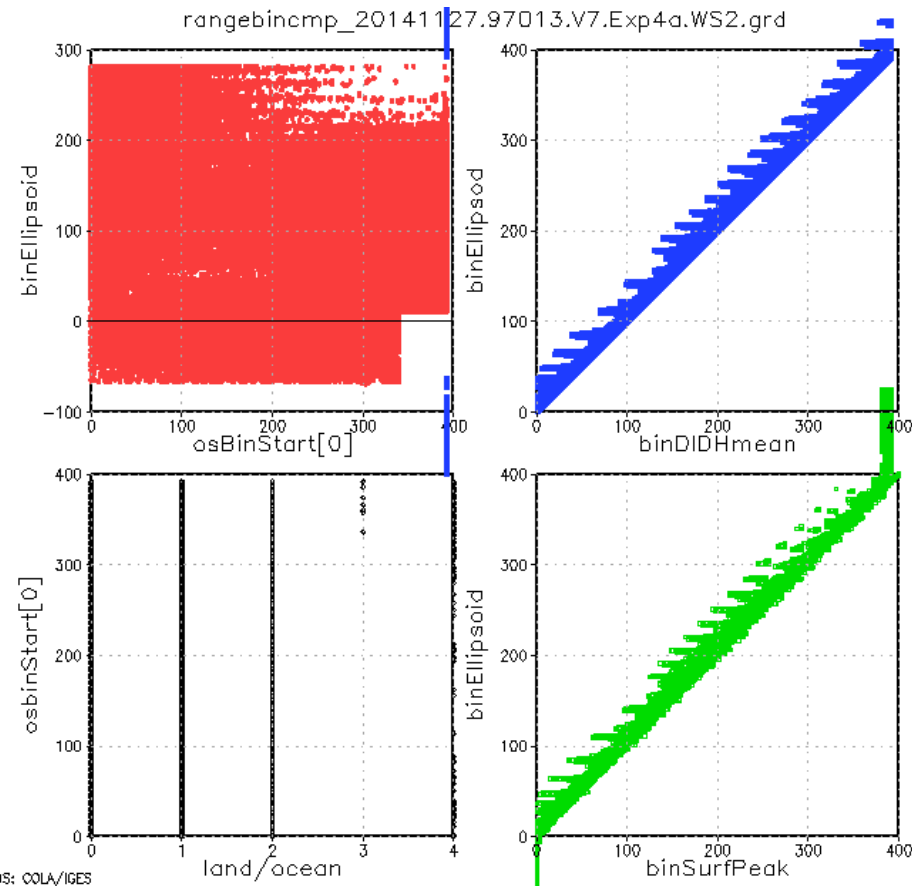


GRADS: COLA/IGES

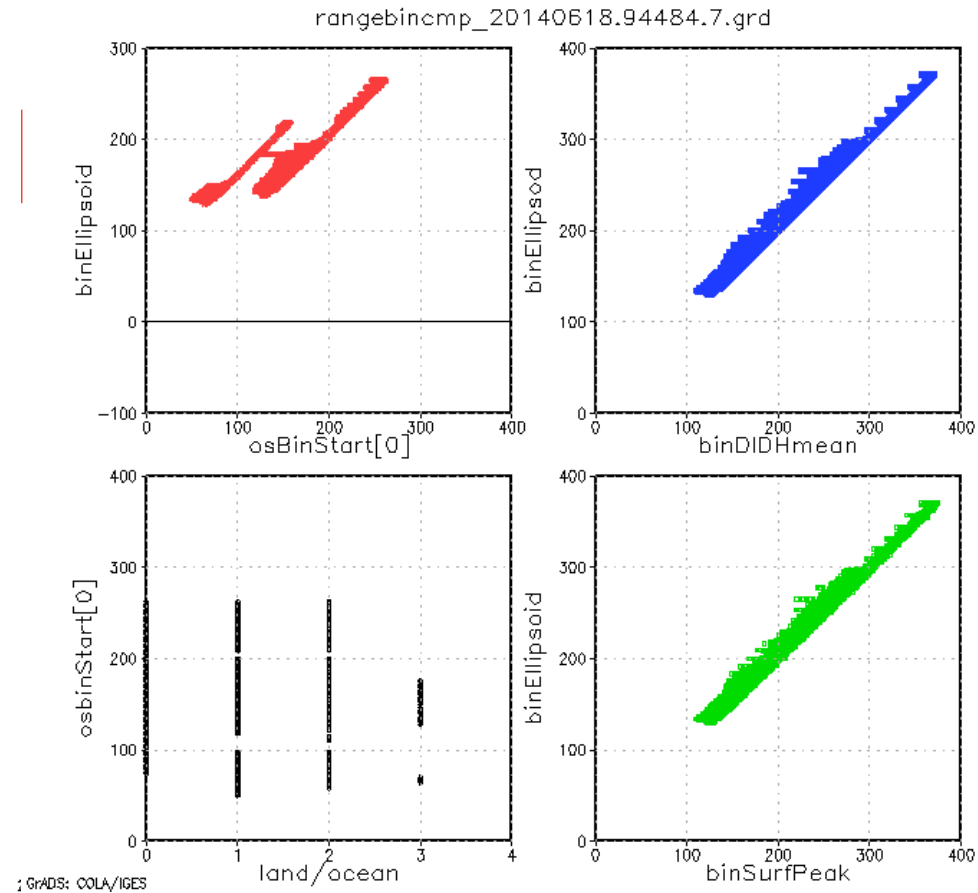
binEllipsoid: range bin of Earth's ellipsoid
binSurfPeak: surface range bin

binDIDHMean: Earth's surface range bin from DEM
osBinSatrt: top range of oversampling

wide swath 2 (Nov. 27, 2014)



normal obs. (June 18, 2014)



	Level 1	Level 2
normal obs. mode	Yes	Yes*
Wide swath	Yes**	No
90 deg Yaw	Yes**	No
Dense sampling	Yes	No*

*: Quantities of estimated rain profile must be evaluated.
rain top height information may not be valid.

** : Over-sampling data are no longer useful.
binSurfPeak, systemNoise, rain flag, etc are not reliable.
Because of above reasons, Level 2 processing was not implemented.